MINING METHODS AND COSTS, CALYX NOS. 3 AND 8 URANIUM MINES, TEMPLE MOUNTAIN DISTRICT, EMERY COUNTY, UTAH

BY W. L. DARE

Information Circular 7811

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W. L. Dare[1/]

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INTRODUCTION AND SUMMARY

This information circular is one of a series the Bureau of Mines plans to publish describing the methods and costs of mining uranium on the Colorado Plateau.

The Temple Mountain mining district is unique among the uranium-producing areas on the plateau. This relatively isolated mining district is in Emery County, Utah, on the eastern flank of the San Rafael Swell, about 35 miles southwest of the town of Green River. The district lies just within the eastern escarpment of the San Rafel Reef - a rampart of rugged and tilted sandstone cliffs that encircles the highly eroded core known as the Sinbad Country. The presence of petroleum matter found associated with the ore deposits, the occurrence of uranium in various formations, and the structural deformation caused by collapsed features have aroused a great deal of geologic interest. Mine development on Calyx Flat is distinctive, in that the ore deposits are worked through 36-inch calyx-drill holes.

The deposits are composed of numerous small, irregular ore bodies. The grade of the ore is erratic, and pods of high-grade ore are often connected with halos of low-grade ore. The uranium-vanadium ores are concentrated chiefly in the lower 30 feet of the Moss Back sandstone member of the Chinle formation. The ore follows the strata in general but not in detail and is mined by open stoping with random pillar support.

This report deals with 2 of the calyx-developed mines; they are 2 of the most consistent uranium producers at Temple Mountain. Calyx No. 3 mine is operated by the American Leduc Uranium Corp., and Calyx No. 8 mine is operated by Cline & Co. Because the ore deposits mined by both companies are very much alike, the mining problems are very similar. Both operations use the same type of equipment. For this reason, the description of the mining practices of both operations could be combined and written as one report. These two operations typify the mining methods and practices employed by many small uranium producers on the Colorado Plateau.

ACKNOWLEDGMENTS

The cooperation and assistance given by the personnel of both American Leduc Uranium Corp. and Cline & Co. toward preparation of this information circular are gratefully acknowledged. Special acknowledgment is given to Leo and Melvin Cline of Cline & Co.; and to J. M. Orr (general manager), Vinton Strickland (mine superintendent), and D. W. Downer (assistant superintendent), all of American Leduc Uranium Corp.

LOCATION AND PHYSICAL FEATURES

Calyx Nos. 3 and 8 mines are in unsurveyed sec. 35, T. 24 S., R. 11 E., Temple Mountain mining district, Emery County, Utah (see fig. 1). The Temple Mountain district is 35 miles southwest of Green River, Utah, and is just within the eastern escarpment of the San Rafael Reef. The San Rafael Reef is a roughly eliptical belt of

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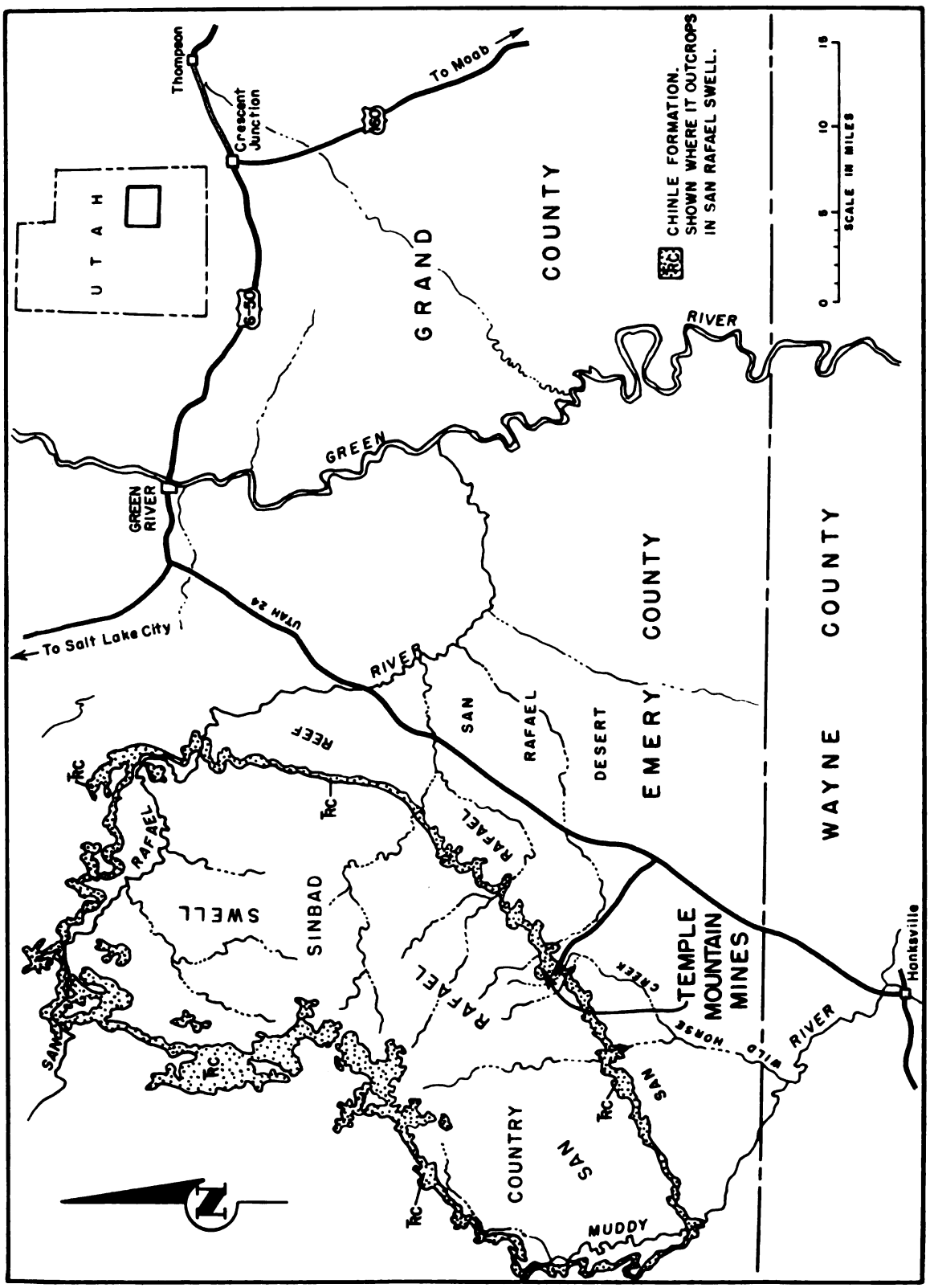

Figure 1. - Location map, Temple Mountain district, Emery County, Utah.
(From Federal Geological Survey Mineral Investigations Field Studies Map MF 16, 1955.)

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massive, tilted sedimentary rocks encircling the heart of the San Rafael Swell. A highly eroded terrain approximately 40 miles long and 15 miles wide within the area bounded by the reef is known as the Sinbad Country. Temple Mountain is a prominent and conspicuous landmark. The San Rafael Desert lies east of the reef.

The Consolidated Uranium Mines, Inc., mine camp is reached from Green River by traveling west 3.8 miles on U. S. Highway 6 and 50; then south on the newly paved Utah State Highway 24 for 32.0 miles to Temple Mountain Junction; and finally 7.3 miles west to the mine camp. The last 1-1/2 miles follows up South Temple Wash Canyon, which cuts through the eastern rampart of the reef. The two mines are about 1 mile north and about 350 feet higher than the mine camp, on a relatively flat bench called Calyx Flat (see fig. 2). Calyx Flat is about 3/4 mile long and 1/2 mile wide, ranging in elevation from about 5,700 to 6,000 feet above sea level. Calyx Flat is bounded on the east by the Wingate and Chinle cliffs, which are part of the reef, and on the northwest by the islandlike remnant of the Wingate and Chinle formations, which form Temple Mountain. North Temple Mountain rises to 6,773 feet above sea level and South Temple Mountain to 6,579 feet.

The sedimentary rocks of the San Rafael Swell have been carved by erosion into a topography that is rugged and picturesque. The more resistant sandstones that form the eastern reef rear suddenly upward as high as 1,800 feet above the San Rafael Desert and are tilted as steeply as 85°. The eastern rampart of the reef has been incised by numerous and impressive washes and canyons. Where the San Rafael River cuts through the Sinbad Country and the reef to the north, the almost shear walls of Black Box Canyon rise 1,500 feet above the river bottom. The beds flatten inside the core where the thicker sandstones, which form the reef, for the most part have been eroded away. Immense erosion has cut the Sinbad Country, leaving mesas, valleys, flats, and canyon lands in random arrangement.

Most of the Sinbad Country is barren of vegetation, except for sage, cacti, and associated growth, although some piñon and juniper grow in the higher areas.

The climate is arid, with summer temperatures often exceeding 100° F. The winters are usually moderate but can be severe in short duration. Winter snows are usually less than 6 inches, and summer rains often occur as heavy downpours. The annual mean precipitation at the center of the swell has been estimated between 6 and 7 inches, with two-thirds of the precipitation occurring between April and October, inclusive.[2/] The mine roads are often muddy and slippery in winter and covered with a thick mantle of dust in summer. There are no perennial streams in the immediate area. The drainage pattern in the area is part of both the San Rafael and Muddy Rivers. The San Rafael River cuts southeasterly through the Sinbad Country about 25 miles to the northeast, and the runoff of lands north of Temple Mountain is part of its system. North Temple Wash skirts the north side of Temple Mountain and drains easterly through the reef, crossing the San Rafael Desert to this river. The Muddy River cuts southeasterly through the Sinbad Country about 15 miles southwest. South Temple Wash, which circles Temple Mountain on the south and west, is part of the Muddy River system and drains south. These two rivers drain most of the San Rafael Swell and eventually empty into the Colorado River southeast of the swell. Water for mining is obtained from a well at the Consolidated Uranium Mines, Inc., camp. Water for domestic use is trucked from Green River.

2/ King, N. J., Mace, M. M., Sedimentation in Small Reservoirs on the San Rafael Swell, Utah: Geol. Survey Circ. 256, 1953, p. 6.

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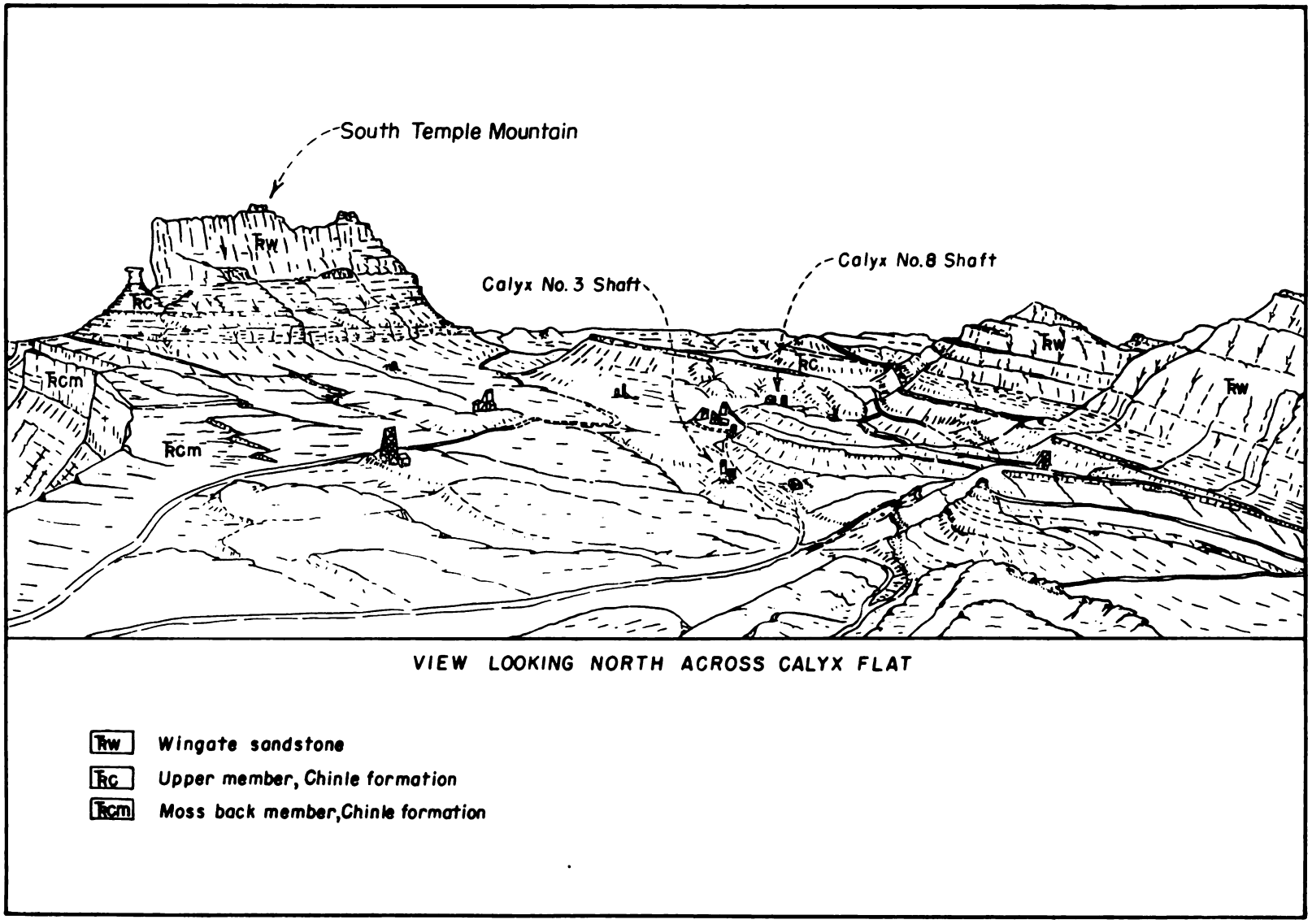

Figure 2. - Perspective sketch of Calyx Flat, Temple Mountain district, Emery County, Utah.
(From figure 4, Atomic Energy Commission Publication RME 3110 (pt. III), Collapse Features, Temple Mountain Uranium Area, Utah.)

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The nearest rail point is on the Denver & Rio Grande Western Railroad at Green River, 43 miles from the camp.

HISTORY AND PRODUCTION

Available information indicates that the Temple Mountain deposits were discovered in 1903. Prospecting and development work was carried on in the area from 1904 to 1913. Mining was begun in 1914. The mines produced an unknown tonnage of high-grade uranium ore between 1914 and 1921. A small tonnage was produced in 1941 and 1942. Mining during the current period was begun in 1948.

J. M. Boutwell[3/] tells of the discovery of "considerable" deposits of a black, vanadiferous sandstone and some carnotite float in "Wildhorse Canyon" by sheep herders in the fall of 1903. He adds that these discoveries were later prospected in 1904 by two men named Browning and Beebe. The material was described as a black, dense, carbonaceous sandstone which contained combustible matter. After burning, it yielded a residue that contained vanadium. Boutwell never visited the discoveries but describes them as southeast of the San Rafael Swell and writes that the deposits were reported to occur in large quantity in a "Cretaceous" formation.

Wild Horse Creek empties into the Muddy River about 15 miles southwest of Temple Mountain. Upstream from the junction the creek passes between the Morrison-capped East and Middle Wild Horse Mesas and then skirts the eastern escarpment of the San Rafael Reef. It splits about 2 miles south of Temple Mountain, with the left fork turning west and cutting through the reef as Wild Horse Creek. The other split continues an additional mile before it enters the reef as South Temple Wash. From Boutwell's brief description of the ore, it is believed that the discoveries he mentions were in the Temple Mountain area, for it is conceivable that the split now called South Temple Wash could have been known earlier as Wild Horse Canyon. The numerous old workings along the outcrop of the Chinle formation in South Temple Wash indicate that the initial discoveries of oxidized ores were easily accessible from the canyon. L. Migliaccio, of Price, Utah, said that oldtimers in the area reported that a frontiersman and stockman named Swazy found the first ore at Temple Mountain about the turn of the century.

Beginning with the 1911 volume of the Mineral Resources of the United States, references to the Wild Horse Canyon deposits became increasingly associated with those at Temple Mountain. Hess in 1911[4/] stated:

> Farther south along the San Rafael Swell considerable development work was done on claims in Wildhorse Canyon. Here carnotite is associated with asphalt and calcium vanadate in sandstone.

In 1912 Hess[5/] wrote:

> A small quantity....has been found on the Browning & Beebe claims at Castle Rock (Wild Horse Canyon) in the southeastern part of the San Rafael Swell, Utah.

3/ Boutwell, J. M., Vanadium and Uranium in Southeastern Utah: Geol. Survey Bull. 260, 1904, pp. 209-210.

4/ Hess, F. L., Mineral Resources of the United States, pt. 1: Geol. Survey, 1911, p. 950.

5/ Hess, F. L., Mineral Resources of the United States, pt. 1: Geol. Survey, 1912, p. 1006.

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In 1914 Hess[6/] reported:

> During the year.....the commercial production of uvanite, a radium-bearing mineral new to science, accompanied by other uranium minerals, one or more of which are yet to be described, was begun at Temple Rock, 45 miles southwest of Green River.

Hess wrote in 1917:[7/]

> The Chemical Products Co. of Denver started work during the year on the uvanite ores from Temple Mountain and had radium salts ready for crystallation.

Continuing, in 1918[8/] he said:

> The Chemical Products Co., of Denver, continued to isolate radium from the uvanite (hydrous uranium vanadate) obtained from Temple Rock, Emery County, 45 miles southwest of Green River, Utah, and bought the claims from Browning and Beebe.

The Chemical Products Co. sold its interests at "Temple Rock" to the Ore Products Corp. in 1919. Moore and Kithil[9/] briefly reported of these deposits in 1916; however, they refer to their location as "Table Mountain." Moore and Kithil were not referring to the prominent mesa 2-1/2 miles southwest of Temple Mountain, named Flat Top Mesa, for Hess in 1922[10/] reported that discoveries on Flat Top Mesa were not made until 1921 and all production before 1922 was from Temple Mountain. In the same article Hess said:

> When the radioactive deposits at Temple Mountain were discovered, it was not the asphaltite that attracted attention, but its oxidation products, for oxidation gives rise to a remarkable series of bright-colored uranium and vanadium minerals that would attract any prospector's attention.

The earliest production of uranium-vanadium ores from the Colorado Plateau was sold for extraction of their radium content. Beginning at the turn of the century, vanadium was used in small amounts for experimentation in steel alloying, most of this work being conducted in Europe. Uranium was also tried for steel alloying in conjunction with vanadium, but the coloring of glass and pottery products was the principal use of the yellow uranium minerals. Before the First World War, European municipalities and hospitals were the principal buyers of uranium and radium produced in the United States. The demand from Europe fell when war started, for European money was channeled to other markets. There was virtually no market for uranium and radium ores produced in this country in 1915. However, the demand for the byproduct

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6/ Hess, F. L., Mineral Resources of the United States, pt. 1: Geol. Survey, 1914, p. 944.

7/ Hess, F. L., Mineral Resources of the United States, pt. 1: Geol. Survey, 1917, p. 955.

8/ Hess, F. L., Mineral Resources of the United States, pt. 1: Geol. Survey, 1918, p. 812.

9/ Moore, R. B., and Kithil, K. L., A Preliminary Report on Uranium, Radium, and Vanadium: Bureau of Mines Bull. 70, 1916, p. 16.

10/ Hess, F. L., Uranium-Bearing Asphaltite Sediments of Utah: Eng. Min. Jour., vol. 114, 1922, p. 273.

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vanadium increased slowly as development of alloy steels progressed. During this period the radium-based material for watch faces was developed and became the principal use for radium in 1917. Production in the Temple Mountain district continued until 1921, when unfavorable business conditions both in Europe and in this country greatly curtailed the market. The production of uranium ores from the Belgian Congo, beginning in 1922, was further responsible for the decreased production from mines on the Colorado Plateau.

L. Migliaccio reported that he, John Davis from Price, and John Adams from Green River mined high-grade oxidized pods exposed along the base of the Wingate sandstone at the northeast end of North Temple Mountain during the summer of 1941 and the spring of 1942. These claims were located by Davis early in 1941. The ore was hand-drilled, sacked, and packed off the mountain by the men to mules below. As a result of this work 6 tons of high-grade ore was sold to the mill at Naturita in 1942. The current period of production began in 1948.

Consolidated Uranium Mines, Inc., began with some 50 claims in 1950 and expanded to control by lease, lease with purchase option, or by mining laws a reported 30,000 acres of land in the Temple Mountain district in 1954. This company operates its properties under a contract-leasing system, and during the last few years has had 8 to 11 producing leases. The lessees supply their own equipment and pay a percentage royalty on the gross value of the ore. The Calyx No. 8 mine is leased by Leo and Melvin Cline, formerly of Cripple Creek, Colo. The Calyx No. 3 mine is leased by American Leduc Uranium Corp. Most of the calyx-drilled shafts were sunk in 1952.

GENERAL GEOLOGY AND DESCRIPTION OF DEPOSITS[11 12 13 14 15/]

General Geology

Temple Mountain lies at the southeast flank of the San Rafael Swell. The swell is a great domal uplift about 100 miles long and 50 miles wide, with its main axis striking northeast. The core of the swell is enclosed in a steep rampart of sandstone cliffs encircling the highly eroded Sinbad Country. The regional strike of the beds in the vicinity of Temple Mountain is about N. 35° E., and the dip ranges from 4° southeast at the north of the mountain to 7° southeast on the south edge of the mining area. The beds steepen toward the reef to the east and flatten toward the center of the swell to the west.

Formations exposed in the immediate area range from the Permian Coconino sandstone to the Jurassic Navajo sandstone (see fig. 3). The Coconino sandstone is ordinarily crossbedded, gray, and fine- to medium-grained. Where it is exposed to the north in Black Box Canyon of the San Rafael River, it is approximately 700 feet thick. The bulk of the overlying Permain Kaibab limestone is dark gray to black, is often sandy, and contains chert concretions with calcite and asphalt cores in the upper part. Ninety feet of this marine limestone has been measured 13 miles south

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11/ Kerr, P. F., Kelley, D. R., Keys, W. S., Bodine, Jr., M. W., Annual Report for June 30, 1954 to April 1, 1955. Part III. Collapse Features, Temple Mountain Uranium Area, Utah: AEC, RME-3110 (pt. III), June 1955, 138 pp.

12/ Work cited in footnote 10 (p. 6), pp. 272-276.

13/ Hemphill, W. R., Photogeologic Map, Stinking Spring Creek - 10 Quadrangle, Emery County, Utah: AEC, TEM-543, April 1954.

14/ Gruner, J. W., Gardiner, L., Smith, Jr., D. K., Annual Report for July 1, 1952 to March 31, 1953, pt. I: AEC, RME-3044, April 1953, pp. 7-12.

15/ Anderson, A. H., and Miller, R. D., Drilling at Temple Mountain, San Rafael Swell, Emery County, Utah: AEC, RMO-829, August 1952, pp. 7-10.

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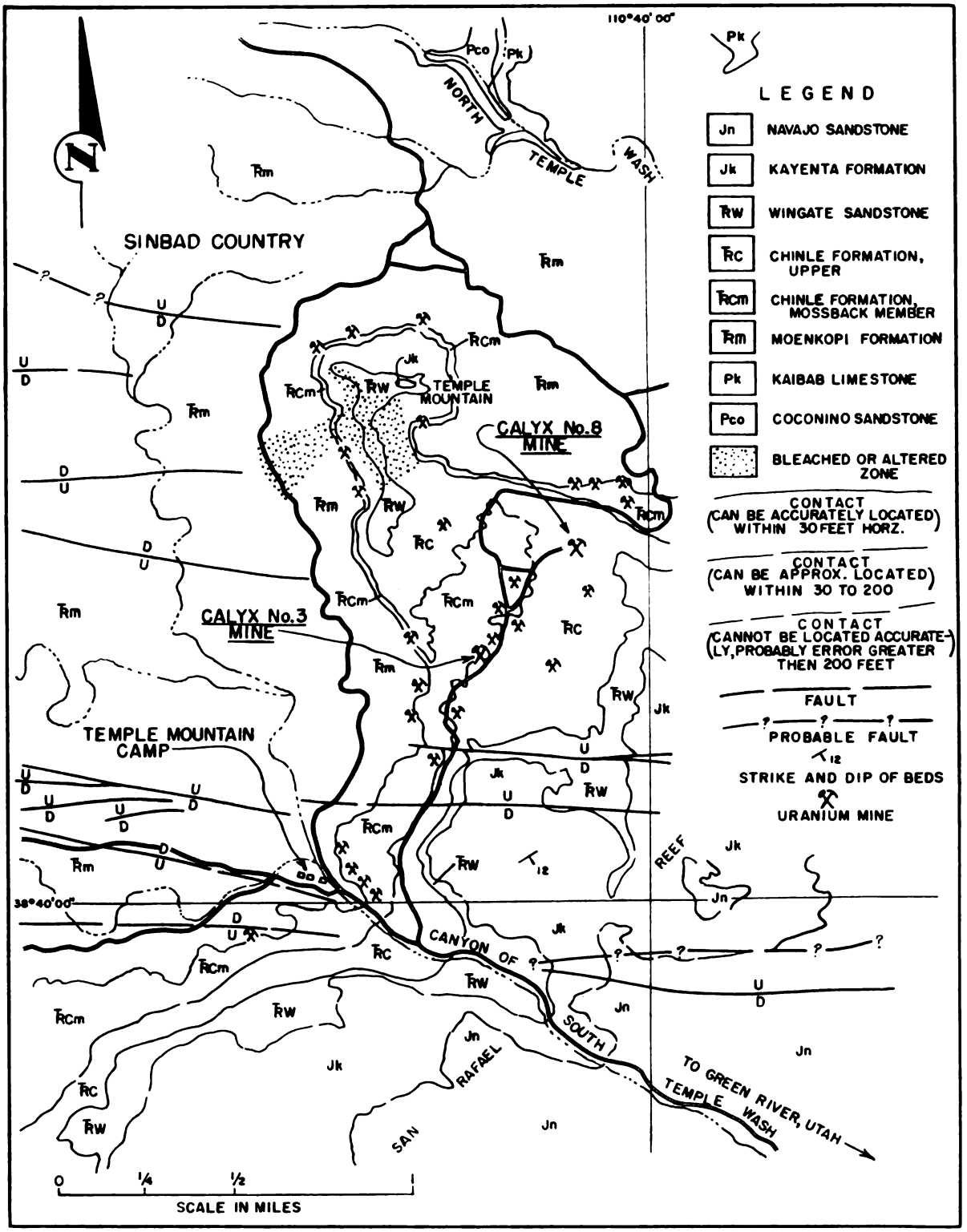

Figure 3. - Geologic map of the Temple Mountain area, Emery County, Utah.
(Traced from Federal Geological Survey photogeologic map, Stinking Spring Creek, 10 Quadrangle, Emery County, Utah.)

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of Temple Mountain. Overlying the Kaibab limestone is the Triassic Moenkopi formation. The Moenkopi is approximately 550 feet thick north of Temple Mountain and is composed chiefly of red to brown shaly siltstone and lenticular beds of fine-grained sandstone. The marine Sinbad limestone member of the Moenkopi is 30 feet thick, buff to gray, and thin bedded. In the vicinity of Temple Mountain it occurs about 90 feet above the base of the Moenkopi. Overlying the Moenkopi is the Triassic Chinle formation. At the base of the Chinle is 25 to 40 feet of gray and maroon siltstone. Within this siltstone is a uniform and continuous stratum of mottled red calcareous sandstone, 4 to 10 feet thick, locally called the "pinto bed." The ore-bearing Moss Back member of the Chinle occurs above this and ranges from 50 to 125 feet in thickness at Temple Mountain, with an average thickness of 100 feet in the mining area. The main part of the Moss Back is a limy, poorly sorted sandstone, with some conglomerate. The upper Chinle ranges from 185 to 265 feet in thickness, averaging 200 feet in the area. It consists of lenticular beds of siltstone, sandstone, mudstone, and conglomerate, principally red and brown. The Triassic Wingate sandstone occurs above the Chinle formation and averages about 360 feet in the Temple Mountain area. The Wingate sandstone is usually orange to buff but in the vicinity has been altered to white and light gray. This massive sandstone forms cliffs and caps much of the higher ground along the reef. The towerlike peaks at Temple Mountain are isolated remnants of the Wingate sandstone. The Jurassic Kayenta formation lies above the Wingate. It consists of about 280 feet of grayish-brown, fine-grained, shaly sandstone lenses, with scattered lenses of mudstone and conglomerate. Only small remnants of the Kayenta remain within the reef in the Temple Mountain area. The Jurassic Navajo sandstone remains only along the reef. In full section it consists of over 400 feet of light-tan, well-sorted, aeolian sandstone.

The area is crossed by a series of faults, which generally strike east-west and are nearly vertical. The vertical throw of these faults ranges from several feet to several tens of feet, with various displacements along their strike. A number of irregular collapse features in the area have complicated the structural geology and have caused odd-shaped surface features. Bleaching and alteration of the rocks are widespread, with the areas near the collapse features most affected. The principal ore deposits occur in the Chinle formation, although uranium-vanadium mineralization has been found in other formations in the area. Ores have been found at the base of the Wingate sandstone and upward for 250 feet. Ore has also been found some 200 feet below the Chinle formation, where drilling has penetrated a broken zone which is part of a collapse feature penetrating the Moenkopi formation. Kerr, Kelley, Keys, and Bodine[16/] have gone into great detail in their study of these features.

Ore Deposits

Petroleum-type organic material is associated with the uranium deposits at Temple Mountain. It occurs along faults and fractures, bedding planes, lithologic contacts, and impregnates permeable strata. It may or may not be uranium bearing. The uranium-bearing material may be a friable, dull-black, greasy petroleum, which forms bands along bedding planes, fills fractures, or occurs along faults, or it may be a hard, friable, dark-gray or black material, which forms pods, pellets, and streaks along bedding planes and fractures. Petroliferous material, which contains no uranium, may occur as a semifluid or fluid, tarlike, brown to black substance. In the fluid form this substance can be seen oozing from the walls at various places at both Calyx Nos. 3 and 8 mines. Much of the semifluid tar impregnates the porous sandstone and imparts a pronounced greasy feel to the rock. Broken particles of this impregnated sandstone seem to "creep" down a muckpile and will stain the fingers.

16/ Work cited in footnote 11 (p. 7).

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The non-uranium-bearing petroliferous material may also occur as brittle, black pellets or streaks. The asphaltite material releases a fetid petroleum odor when first broken. This is especially noticeable in stopes where high-grade ore is being mined.

The asphaltic-ore bodies in the Moss Back member of the Chinle formation are usually found in the more massive sandstones. The conglomerates are also mineralized when within this main sandstone stratum. The ore occurs in a series of closely spaced, high-grade pockets surrounded by halos of low-grade ore, which sometimes connect the high-grade pods. The ore varies in thickness, following the beds in general, although not in detail. The ore in places appears to be controlled by structural features. At the Calyx No. 8 mine ore has been found to follow along northwest-striking fractures. Most of the ore is present at the base of the Moss Back near its contact with the lower siltstones and mudstones. However, at both mines, ore has been found occasionally on an upper level which is 20 to 30 feet above the contact. One of these areas is about 300 feet northeast of the Calyx No. 3 shaft. Occasionally, the ore pods overlap, and sometimes there is a noticeable split in the ore sandstone with ore occurring above and below barren mudstone. The ore at one point in the Calyx No. 8 mine seemed to roll sharply upward to form an ore pod some 20 feet thick. Conglomerate and mudstone lenses overlie the host sandstone. Figure 4 is a picture of a low-grade ore pillar at the Calyx No. 3 mine. In the picture the ore sandstone is noticeably crossbedded. At the back the sandstone forms an irregular, wavy contact with a conglomeratic lens, with this lens abutting mudstone on the left. The darker patches exposed on the pillar are higher grade ore.

Tree logs, which have a core of silica and an outer rim of carbon and pyrite, are found principally in the conglomerates but are seldom mineralized.

The unoxidized asphaltic ores mined at Temple Mountain are reported to contain uraninite within the petroleum mass.[17/] The ratio of U_3O_8 to V_2O_5 of the ore produced from the Calyx No. 3 mine during the period for which mining costs were tabulated was 1:2.6. Production from Calyx No. 8 mine averaged 1:2.7.

METHOD OF EXPLORATION

The initial exploratory drilling program was carried on by the Atomic Energy Commission from December 1951 to July 1952. In the first part of this program 1,126 holes were wagon-drilled, 762 of which were drilled in the Calyx Flat area. Thirty holes were diamond-drilled in the second part of the program, 26 of which explored the Calyx Flat area. The wagon-drill holes averaged 85.4 feet in depth, and the diamond-drill holes (which, for the most part, were drilled along the eastern edge of the flat) averaged 181.7 feet in depth. Immediately following this program, Consolidated Uranium Mines, Inc., developed the Moss Back ore bodies by drilling the calyx shafts. Afterward, this company carried on a continual wagon-drilling program to prospect for new reserves.

American Leduc Uranium Corp. conducts its own drilling program and employs the services of contract drillers. The contractor employed in January 1957 had his percussion drill mounted on a flat-bed Army-type truck (see fig. 5). This rig has a 20-foot hinging mast mounted on the front of the truck and a 365-c.f.m. Gardner-Denver compressor mounted on the bed. The Gardner-Denver D-89 rock drill is chain-fed.

17/ Weeks, A. D., and Thompson, M. E., Identification and Occurrence of Uranium and Vanadium Minerals from the Colorado Plateau: Geol. Survey Bull. 1009B, 1954, pp. 20-21.

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Figure 4. - A low-grade ore pillar at Calyx No. 3 mine.

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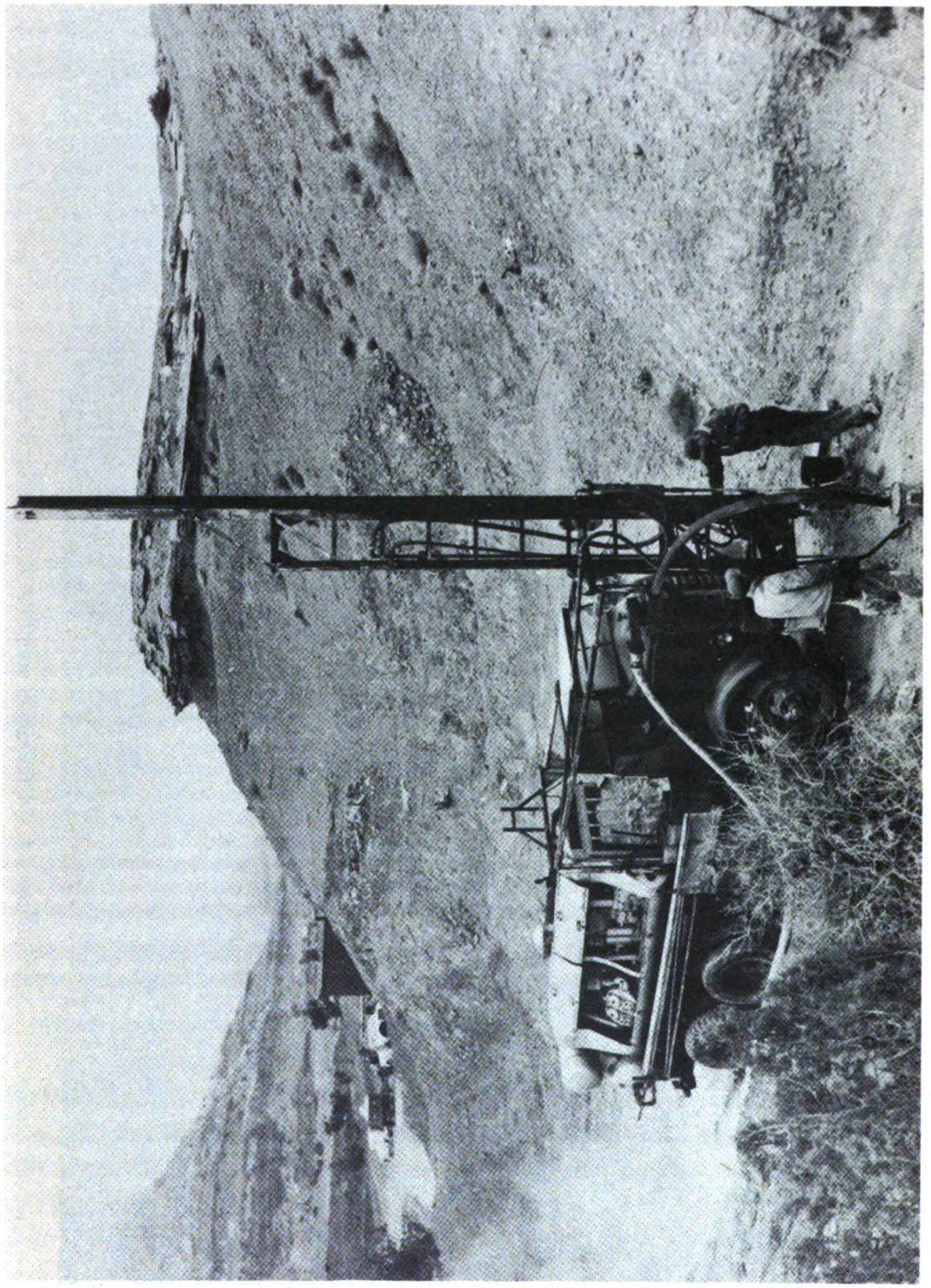

Figure 5. - Exploring for additional ore with a truck-mounted percussion drill southeast of Calyx No. 3 shaft.

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Fifteen-foot lengths of 1-1/4-inch round steel and 3-1/4-inch tungsten carbide insert-type bits are used.

Drill cuttings are caught in a cyclone-type collector mounted on the side of the truck. The driller takes composite samples, representing 5-foot intervals, from the collar of the hole to near the top of the ore zone. These cuttings are taken to give the driller a running log of the ground he is penetrating. When in the ore zone he empties the collector every foot and bags a grab sample from the cuttings of each interval. The holes are bottomed in the red mudstones and siltstones beneath the Moss Back member. Because of caving ground the holes are probed immediately after they are bottomed.

Typical contract wagon-drilling costs in the area range from $0.60 to $0.70 per foot for depths to 100 feet and from $0.75 to $0.85 for depths greater than 100 feet.

METHODS OF DEVELOPMENT AND MINING

Development

Both mines are developed by small-diameter circular shafts, sunk with a truck-mounted, 36-inch-diameter calyx drill. The Calyx No. 3 shaft is 117 feet deep, with the station level at 105 feet; the Calyx No. 8 shaft is 155 feet deep, with its level at 135 feet. Both shafts are lined with 12-gage sheet steel for a short depth below their collars to prevent caving of the less consolidated surface material. The shafts were sunk, for the most part, through sandstone. The walls of the shafts are smooth and stand well. Small amounts of rock have broken out of the walls where minor lenses of shale were penetrated.

Calyx Flat is dotted with many small calyx shafts. It was the belief of Consolidated Uranium Mines, Inc., that this relatively cheap method of developing the individual ore bodies eliminated the need of crosscutting from one ore body to another, minimized haulage distances, and provided a unit operation for each lessee. To initiate production, the ore bodies were not completely delineated when the shafts were drilled. It later developed that some of the shafts could have been located to better advantage relative to the center of the ore bodies or to underground haulage grades. The depth of the calyx shafts on Calyx Flat ranges from 84 to 208 feet.

Both operating shafts were sunk through the ore, and ore pillars were left at the stations. At the Calyx No. 8 mine the man-trip opening from the shaft to the station is a slot through the shaft pillar about 6 feet high and 2 feet wide, with the loading chute on the opposite side. The man-trip opening and loading chute are both on one side of the shaft pillar at the Calyx No. 3 mine.

Many mines in the area have interconnected workings. Those of No. 8 connect with those of No. 11 to the south. The workings of the Calyx No. 3 mine are actually the combined workings of Calyx Nos. 3, 10, and 12 shafts, with those of No. 10 connecting with No. 9 to the north. Calyx No. 12 shaft is the deepest on Calyx Flat, with a total depth of 208 feet and a station depth of 196 feet. A 4- by 5-foot cribbed raise connects the mine workings near the No. 12 shaft to the surface. The interconnected mine workings with various surface entries provide a certain amount of natural ventilation along the principal haulageways.

The calyx shafts were sunk for $35.00 a foot by the Cannon Drilling Co. of Green River. Between June 27, 1952, and August 10, 1952, the Calyx No. 8 shaft was

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drilled 155 feet deep and completed in 19 working shifts for an average advance of 8.2 feet per shift. Some trouble was experienced in the ore zone when penetrating the sticky asphaltic lenses, but this was overcome by using a solvent to clear the asphaltic material from the cutting face. The present cost of sinking a similar shaft is reported to be $40.00 to $45.00 per foot, depending on the site of the shaft and the footage to be drilled.

Mining

The ore is mined by open stoping, with random pillar support. The irregularity of the ore is illustrated by the labyrinthlike plan of the underground mine workings (see figs. 6 and 7). The ore pods sometime roll sharply and often appear to be controlled by fractures and by the mudstone and siltstone contacts. The ore often splits into two separate horizons, with waste between them. Surface drilling ahead of the existing workings is important for indications of additional ore, but equally important are the skill and judgment of the miners to recognize the sometime erratic ore trends.

Pillars do not follow any particular pattern, for their spacing and size depend on the width of the span and the nature of the overlying rock. Irregular pillars of waste are left for support where waste islands are encountered within the larger ore bodies. Ore pillars are left sparingly. The rock overlying the ore consists of barren conglomerate or mudstone and sometimes barren or low-grade sandstone. The mudstone sloughs easily. The lenses of conglomerate, for the most part, stand fairly well, although slabs will break loose if the contact with an overlying mudstone is exposed. The sandstone stands well; if possible, the miners do not break to a mudstone but attempt to leave some low-grade sandstone in place. Timber has been used in isolated instances to support the mudstone. There is very little evidence that the timber stulls take any great weight. Their principal purpose is to prevent further air slacking and sloughing.

The maximum thickness of ore mined at both operations has been about 20 feet. Where the ore has been found to split, additional ore has been found in what was thought to be worked-out stopes. At the Calyx No. 3 mine, 2 to 4 feet of ore was mined from the bottom of an old stope after an ore seam was noted to trend downward. If the bottom of a stope is in sandstone, down holes are drilled across the bottom, to make sure that no ore remains. In general, if a consistent gray or gray-green mudstone is exposed beneath the ore sandstone, there is little chance of additional ore occurring beneath this contact.

Blending of ores is important and is stressed at both mines. By blending high- and low-grade ores the deposits are made to yield a maximum tonnage and a greater final return on investment capital. Sale of much of the low-grade ores would not be possible if the ores were not blended. At the Calyx No. 3 mine the superintendent attempts to maintain the uranium content of the ore between 0.20 and 0.25 percent U_3O_8. The Calyx No. 8 mine strives to maintain a grade that is as near as possible to 0.25 percent U_3O_8. When low grade is encountered in a stope, production from this area will stop until it can be concurrently mined with higher grade ore. Conversely, when high-grade ore is opened up, it will not be hoisted until it can be used to advantage to raise the grade of marginal ore to an average-grade product. By hauling from high- and low-grade stopes, the ore is blended as alternate buckets are hoisted to the surface. The minimum grade that Cline & Co. will deliberately break is 0.14 to 0.16 percent U_3O_8. Selective mining is practiced when in thin ore.

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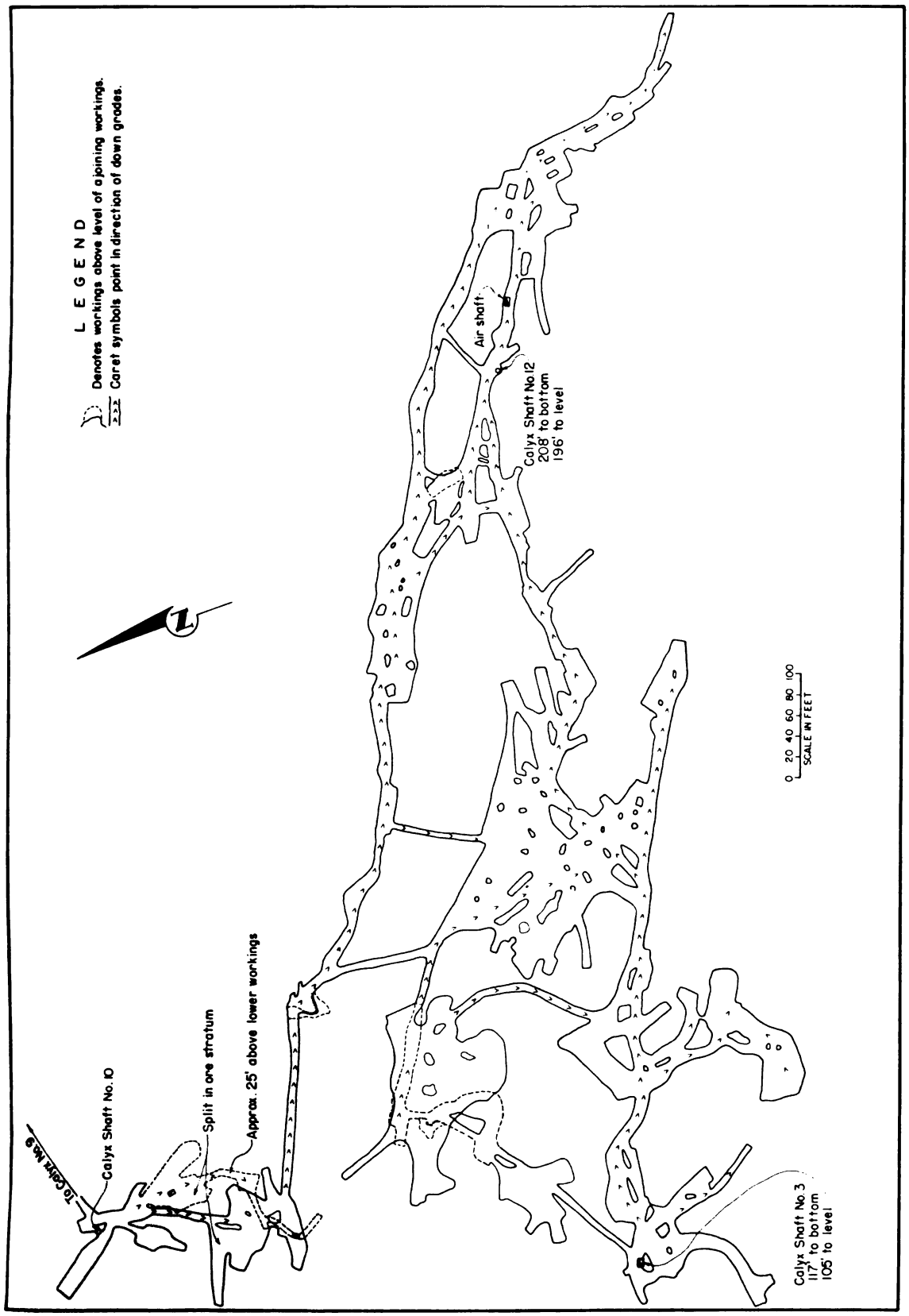
LEGEND
Denotes workings above level of adjoining workings.
Caret symbols point in direction of down grades.
To Cayuga No. 9
Calyx Shaft No. 10
Split in ore stratum
Approx. 25' above lower workings
Air shaft
Calyx Shaft No. 12
208' to bottom
196' to level
Calyx Shaft No. 3
117' to bottom
105' to level
0 20 40 60 80 100
SCALE IN FEET

Figure 6. - Plan map of underground workings, Calyx No. 3 mine.

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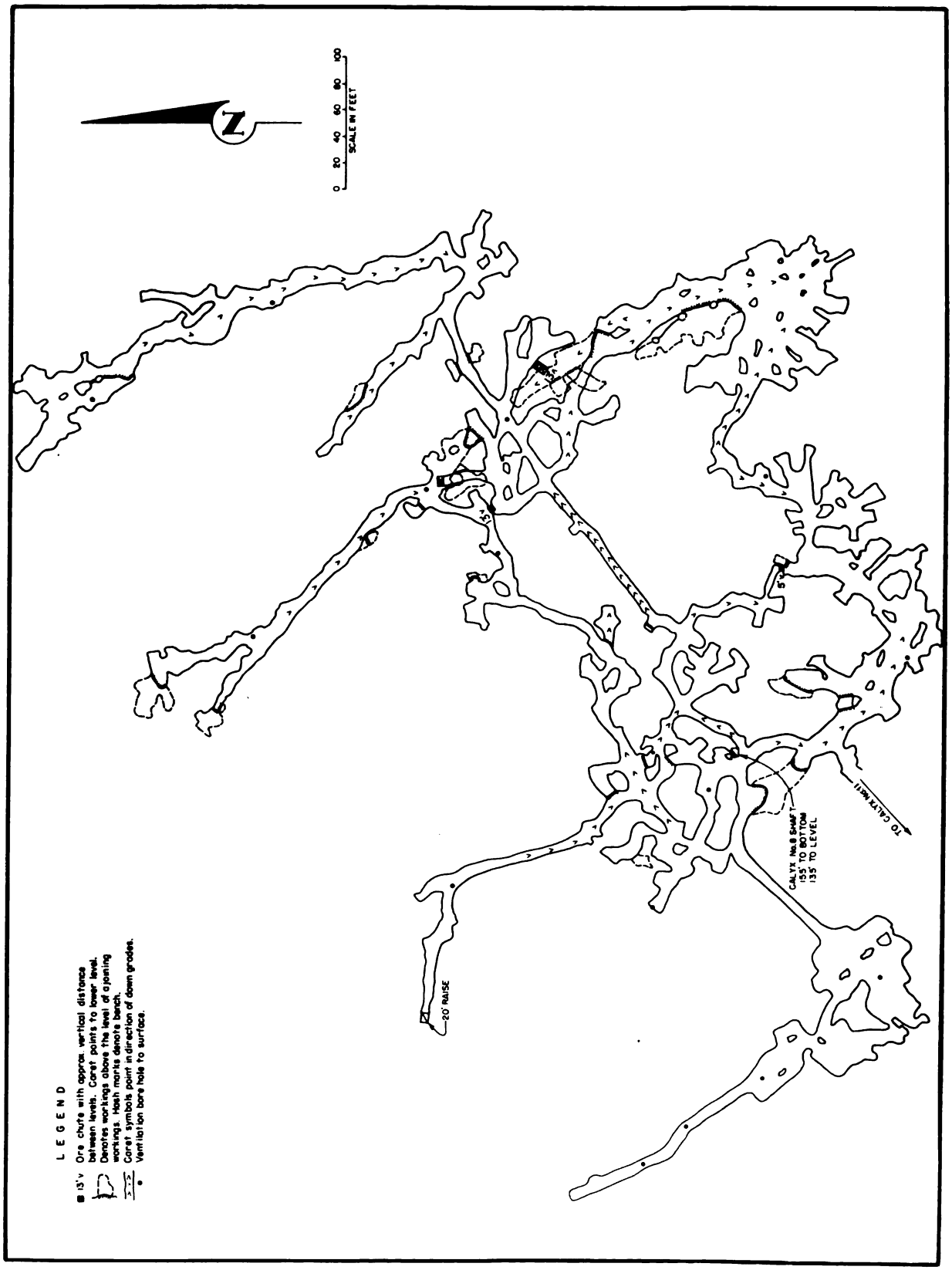
N
0 20 40 60 80 100
SCALE IN FEET
LEGEND
13'v Ore chute with approx. vertical distance between levels. Caret points to lower level.
Denotes workings above the level of opening workings. Hash marks denote bench.
Caret symbols point in direction of down grades.
Ventilation bore hole to surface.
20' RAISE
CALYX No. 8 SHAFT
155' TO BOTTOM
135' TO LEVEL
TO CALYX No. 11

Figure 7. - Plan map of underground workings, Calyx No. 8 mine.

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Haulageways are driven 6 to 7 feet high and 6 to 7 feet wide; in ore, they may be driven larger. These development drifts are advanced along the bottom of the ore and on gradual although variable grades. To extend a haulage route through a stoped area the bottom is often cut or filled to make an even grade. Development of an ore body found by surface drilling can be done on a predetermined grade; but when exploratory drifts are driven following an ore lead, the grade of the drift sometimes must be modified as it is advanced.

When developing an ore body discovered by surface drilling, the operators attempt to take advantage of the dip of the ore body by intersecting it along its downdip side. Then, when they drive into the ore, they advance updip and slush downdip. From the haulageway at the Calyx No. 3 mine, the initial rooms are driven into the ore roughly perpendicular to the haulageway and extended to the full height of the ore and about 7 feet wide. The width between the rooms depends on the width of the ore. They may be as much as 40 feet apart. After these initial rooms have been advanced some 30 to 40 feet into the ore, the ore between the rooms is slabbed to the free faces provided. The actual procedure will vary somewhat with the conditions encountered. The miners must continually watch for ore trends to keep dilution with waste to a minimum, for the ore may cut off drastically and take another unforeseen direction. Close attention to drill cuttings is vital. It may be necessary to shorten a round if light-color drill cuttings, which indicate waste, are encountered. When waste is found inside the ore body, the miners drive around it, leaving it as a pillar. It is important to recognize changes in the grade of the ore, for when it is necessary to establish an ore pillar, they naturally prefer to leave low grade. Aside from the fact that low-grade ore represents less money left in place, the harder low-grade makes a better pillar.

Where the ore is very erratic, mining is simply a matter of following the ore. Color is the primary guide in following the ore, but its feel can also be helpful. The color of the petroliferous ore may be black, brownish-black, gray, or intermediate shades. Waste rock can be of similar colors, and a miner not familiar with the deposits can easily mistake waste for ore. A sandstone can be impregnated with a nonuranium-bearing, semifluid, brownish-black petroleum matter the exact color of ore, and often only by feeling it can the difference be noted. This material usually has a slightly greasy feel; if it contains much petroleum matter, it tends to "creep" when it moves down a muck pile. The fetid odor of the ore can also be used to tell it from waste. A miner is frequently seen checking the ore by its "stink." The same problem is experienced when drilling, for black cuttings may or may not indicate ore. In general, if the rock being penetrated is ore, the black cuttings will leave a brownish-black or grayish-black band down the center of the water mark below the collar of the hole. If the black material is deposited as 2 thin bands, 1 along each outer edge of the water mark, the bit is probably cutting rock which contains non-uranium-bearing petroleum matter.

The operators are not completely recovering ore pillars. When a stope has been mined out, they decrease the size of the pillars for maximum recovery, but not to a point where caving occurs. By keeping the workings open, later reentry and mining of submarginal material are possible.

Drilling is done using jack-leg-mounted drills (see figs. 8 and 9). This type of drill is adaptable to these deposits where drill holes must be angled in various directions from frequently awkward positions. Their light weight is an advantage where the drill must be moved often. Both operations use 7/8-inch hexagonal drill steel with integral 1-5/8-inch, tungsten carbide, insert-type chisel bits. Steel length preferred at the Calyx No. 3 mine is 6-foot for standard heading rounds and

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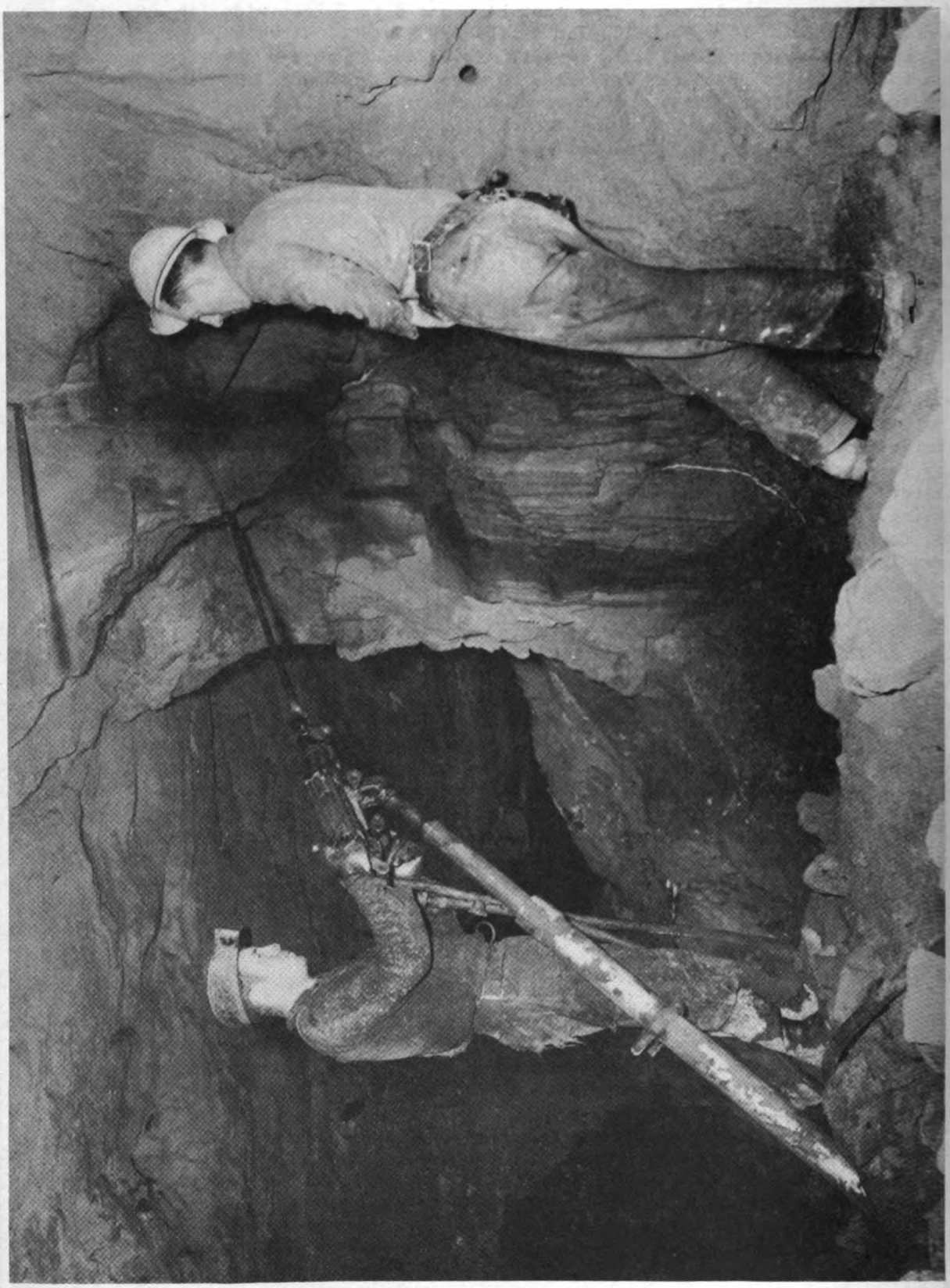

Figure 8. - Drilling a slab round in an ore pillar, Calyx No. 8 mine.

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Figure 9. - Drilling a slab round at Calyx No. 3 mine in ore averaging about 6 feet thick.

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8-foot for slab rounds. At the Calyx No. 8 mine steel in 5-foot 3-inch lengths is used. When drilling very soft ground, the miners at Calyx No. 8 mine report an increased drilling rate by using 1-1/4- and 1-1/8-inch, 4-wing, 1-use-type bits.

Standard drill rounds vary but usually are patterned around either a 3-hole or 5-hole burn cut (see fig. 10). The 3-hole burn cut is used principally to break soft friable ore and is drilled either with the 3 holes placed as a triangle or in line. The 5-hole burn cut is used to break harder ore or the usually harder waste. Cut holes are spaced 4 to 6 inches apart. Reliever and trim holes are spaced a maximum of 24 inches apart in the softer ore and 14 to 18 inches apart in the harder ground. Holes in slab rounds are spaced 2-1/2 to 3 feet apart. Both mines use 45-percent semigelatin dynamite, No. 6 caps, and safety fuse. The hoistmen make the primer cartridges, which are taken underground near the end of the shift. The superintendent at the Calyx No. 3 mine reported that he plans to start experimenting with 35-percent semigelatin dynamite in the near future.

Short exploratory holes, drilled 15 to 20 feet deep with the jack-leg-type machines and 7/8-inch hexagonal steel in 4-foot sectional lengths, aid in the search for nearby ore extensions at the Calyx No. 8 mine and are helpful in determining ore trends.

Compressed air is delivered underground through 2-inch pipe, which is hung down 4-inch drill holes from the surface. Two-inch flexible hose is used in some of the larger stopes at the Calyx No. 8 mine.

Scrapers are used to transport the ore through the stopes. Scraper hoists are 5- and 7-1/2-horsepower and equipped with 24- and 30-inch scrapers. Although scraping distances are usually less than 100 feet, the ore is sometimes scraped a maximum of 150 feet. On the longer hauls the ore is moved in relay, first by a skid-mounted scraper in the stope and then by the scraper mounted on the loading ramp. At the Calyx No. 3 mine, the ore is first gathered about 30 feet back from the face, with the pinholes spaced across the face about the width of the scraper bucket apart. About 6 inches of fines is left on the bottom, which allows the driller to set his air leg more easily as he begins his next round. The tail sheave of the slusher which transports the ore to the loading point is hung on a chain hung behind the ore pile.

The mine workings are dry, except for a few slight seeps during the spring.

Transportation

Scoot-Crete Haulage

The ore is transported underground at both mines by model D-52 Scoot-Cretes. This haulage unit is mounted on 3 rubber-tired wheels, has a dumpbox capacity of 18 cubic feet, and is powered by a 10-horsepower diesel engine (see fig. 11). The Scoot-Crete is built by Getman Bros. Manufacturing Division, South Haven, Mich., and was developed from the original units designed to haul construction materials, such as mixed concrete. The driver sits over the single rear steering wheel, and the dumpbox is mounted over the two front-drive wheels. The box, hinged to tip forward, is dumped by hand. This ore buggy is equipped with 7.50- by 10-inch, 6-ply tires. The model D-52 Scoot-Crete is 43 inches wide, 103 inches long, and 56 inches high. The loading height of this vehicle is 43 inches. The 10-horsepower, 1-cylinder, 4-cycle, air-cooled, series 612 Deutz diesel engine is built by Kloeckner-Humboldt-Deutz A.G. of Cologne, Germany. Because of its greater power and lower maintenance cost, the

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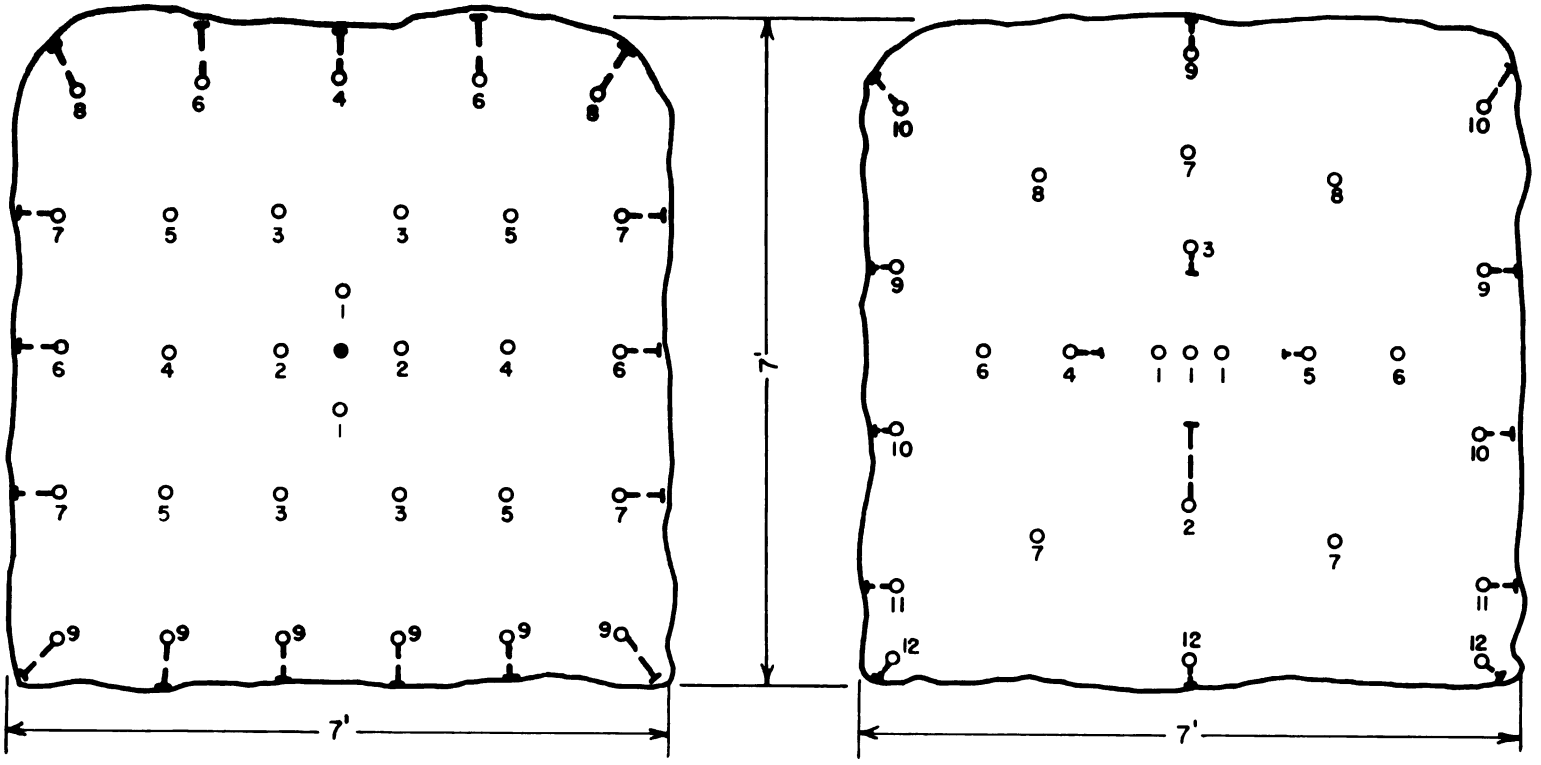
7'
7'
7'
32-HOLE ROUND WITH A 5-HOLE BURN.
THIS ROUND USED AT THE CALYX NO. 8
MINE WHEN IN HARDER GROUND.
0 1 2 3 4 5
SCALE IN FEET
26-HOLE ROUND WITH A 3-HOLE BURN.
THIS ROUND USED AT THE CALYX NO. 3
MINE WHEN IN SOFTER GROUND.
NUMBERS DENOTE BLASTING SEQUENCE

Figure 10. - Typical heading rounds used at Calyx Nos. 3 and 8 mines.

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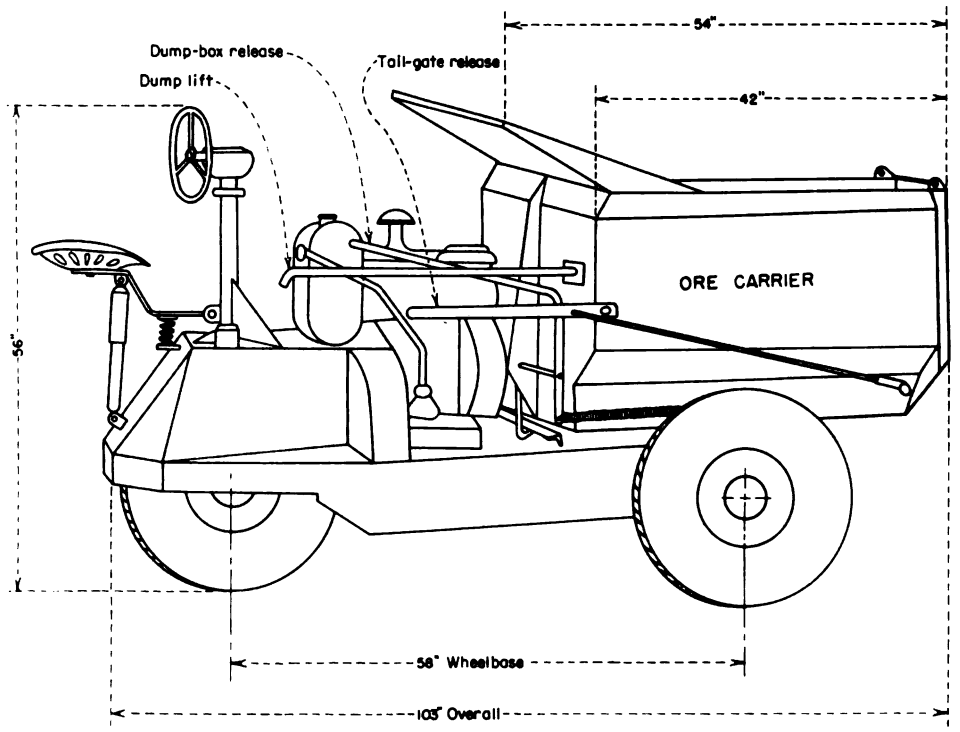
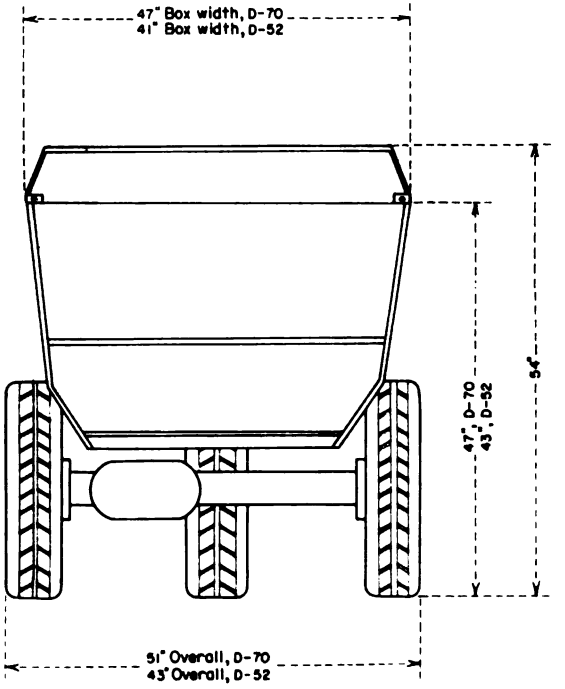
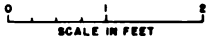


SIDE OBLIQUE VIEW



END VIEW



SPECIFICATIONS

Box capacity, struck – D-52, 18 CU. FT.; D-70, 21 CU. FT.
Carrying capacity – 3,000 pounds
Engine – Deutz, diesel, 1-cylinder, 4-cycle, air-cooled, 10-H.P.
Transmission – 4 speed forward, 4 speeds reverse; V-belt, 3, drive from engine
Turning radius – 67 inches, overall
Tire size – 7.50 x 10 or 7.50 x 25
Exhaust cooler not shown

Figure 11. - Dimensional drawing of Scoot-Crete Ore Carrier.
(Courtesy, Getman Brothers, Manufacturing Division, South Haven, Mich.)

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mine operators prefer this foreign-built engine over the 1-cylinder, 2-cycle engine the builder installed in the earlier models. A belt drive connects the engine to the transmission, which has four speeds forward and reverse. A model D-52 Scoot-Crete costs approximately $2,460.00 in Grand Junction, Colo., in February 1957.

The builder reports that this vehicle can negotiate a 25-percent grade. The maximum grade of Scoot-Crete haulageways at both the Calyx Nos. 3 and 8 mines approximates 20 percent. Experience has shown that these vehicles can pull the steeper grades more easily when loaded than when empty, because of the increased traction on the drive wheels. Lining the bottoms of the dumpboxes with 3/4-inch steel plate has increased the traction of the drive wheels of buggies used at Calyx No. 3 mine.

For maximum efficiency the haulageways must be clean and smooth, a fact that becomes increasingly important as the grade is increased. To provide solid traction on grades that are 10 percent or steeper, the drifts are lagged across the bottom with 3-inch timber. Water sprayed on unlagged bottoms allays the dust and also helps to form a compact rolling surface. As a safety precaution on the longer grades, the Scoot-Crete operators at Calyx No. 3 mine drive backward going upgrade and forward going downgrade, so that, should the vehicle break away, they can leave it from its uphill end. In the opinion of the mine operators, a disadvantage of the Scoot-Crete is its braking design.

These small, mobile, haulage units are adaptable to many of the small undulating uranium deposits mined on the Colorado Plateau. In many small deposits, particularly in the Morrison formation, underground exploration, development, and mining cannot always be clearly differentiated, for the ore or ore leads must be followed along their irregular trends and mined as found. Because there is little advance information on the direction the ore may take next, it is essential to stay on the ore, which results in an uneven, irregular haulage course. It is often difficult to establish a rail-haulage level in the ore stratum, and in small deposits it may be financially unwise to develop a haulage level beneath the ore. Where it is necessary to hoist and lower mine cars along an uneven and changing grade, mobile haulage units, such as the Scoot-Crete, may eliminate an awkward rail-haulage system. Their operating height (the height of the driver is 6 to 6-1/2 feet) is an advantage in thin ore. As each vehicle is a single haulage unit, it does not depend on other units. However, operating and maintenance costs can be considered relatively high. Because it is necessary to have standby or additional units ready to put into production, the investment cost per ton of carrying capacity is also relatively high. As is necessary when any type of diesel-powered equipment is used, forced ventilation is essential.

The Scoot-Cretes are loaded at scraper slides (see fig. 12). The slides are either movable steel ramps, generally mounted on two rubber-tired wheels, or are semipermanent structures built of timber. Usually, timber slides are constructed at the entrance to larger stopes, and the movable slides are used in smaller stopes or when small headings are driven. In small headings these steel slides are placed about 40 feet from the face. The scraper hoists are mounted on the rear of the slides and powered by 5-horsepower, compressed-air operated motors. The scrapers are 24-inch, and the cable is 3/8-inch by 19 wire.

Generally, 2 haulage units can haul enough ore to keep the hoist busy, if the average haulage distance is no more than 400 feet. If a larger capacity hoisting system were used, it follows that more than two operating units would be necessary. Only one Scoot-Crete is used to haul from each stope because of the restricted area

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Figure 12. - Loading a Scoot-Crete at a scraper slide, Calyx No. 8 mine.

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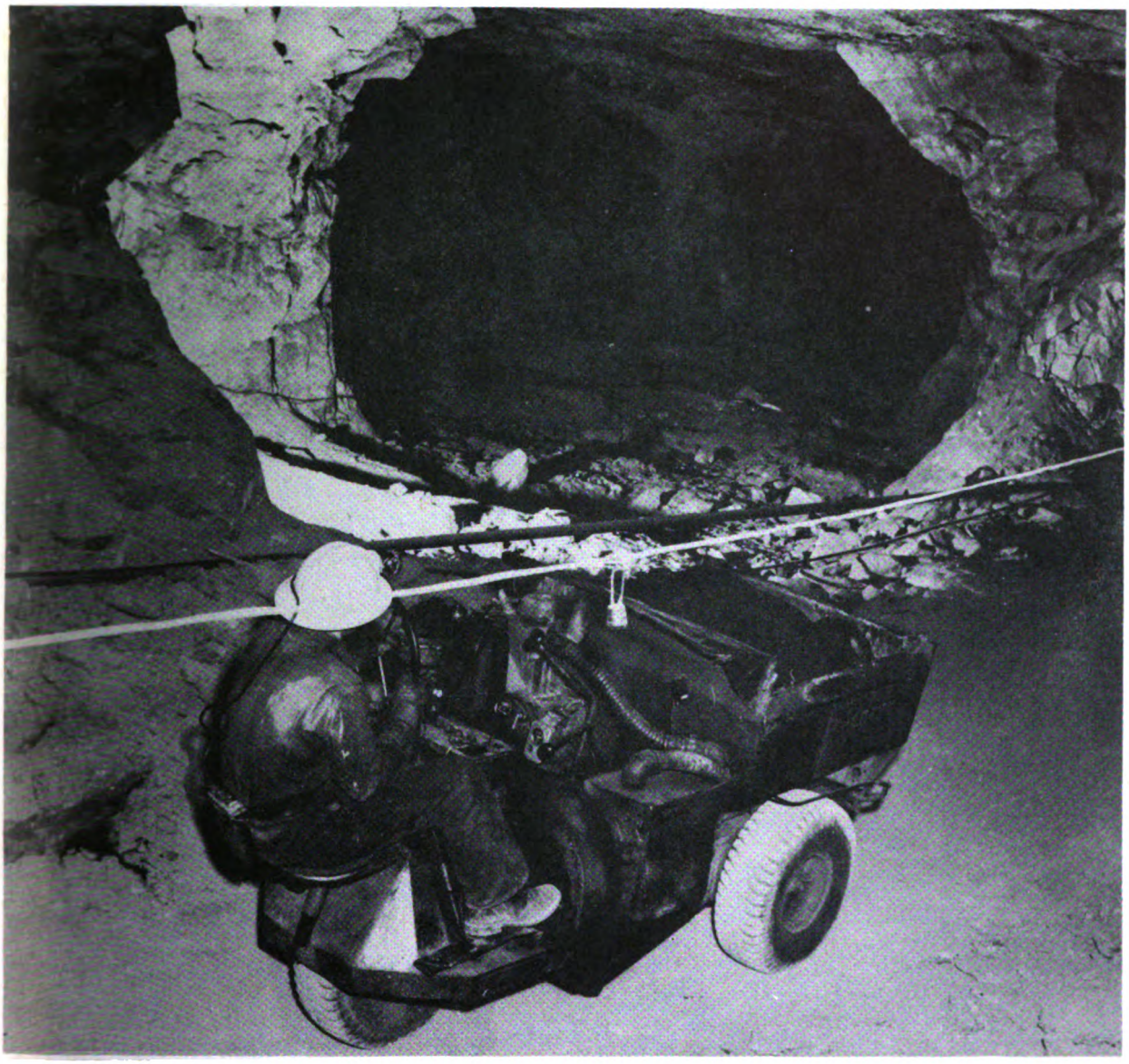

Figure 13. - Transporting a load of ore through an open stope in Calyx No. 3 mine.

of much of the haulageways and because blending ores from various stopes is always in progress. Figure 13 shows a Scoot-Crete hauling ore through an open stope. Maximum haulage distance at the Calyx No. 8 mine during the summer of 1956 was about 800 feet. Where ore was being hauled from an area about 40 feet from the shaft at the Calyx No. 3 mine, 2 units each averaged 50 to 55 trips a day, each traveling approximately 5 miles a shift.

At the shafts the ore is dumped from the Scoot-Cretes into small timber chutes, from which it slides directly into the hoisting bucket below the station level (see fig. 14). One load fills the hoisting bucket. At the Calyx No. 8 mine the bucket rests on its side on timbers below the chute and at the same angle as the chute (see fig. 15). The bucket attains the correct position by striking and sliding down a timber door, which is hinged to rest at an angle across the shaft. Below the chute

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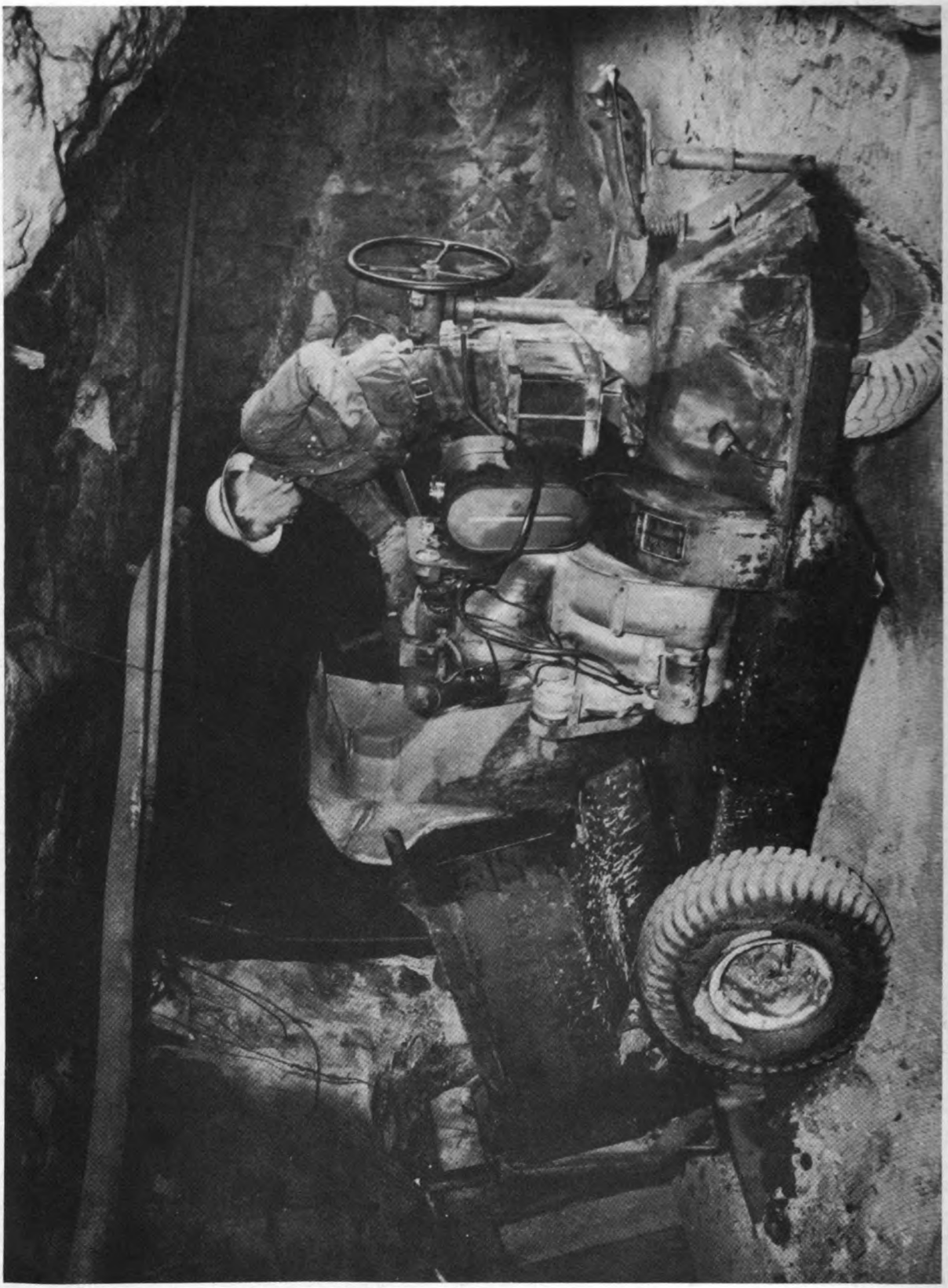

Figure 14. - Dumping a Scoot-Crete at Calyx No. 8 shaft station.

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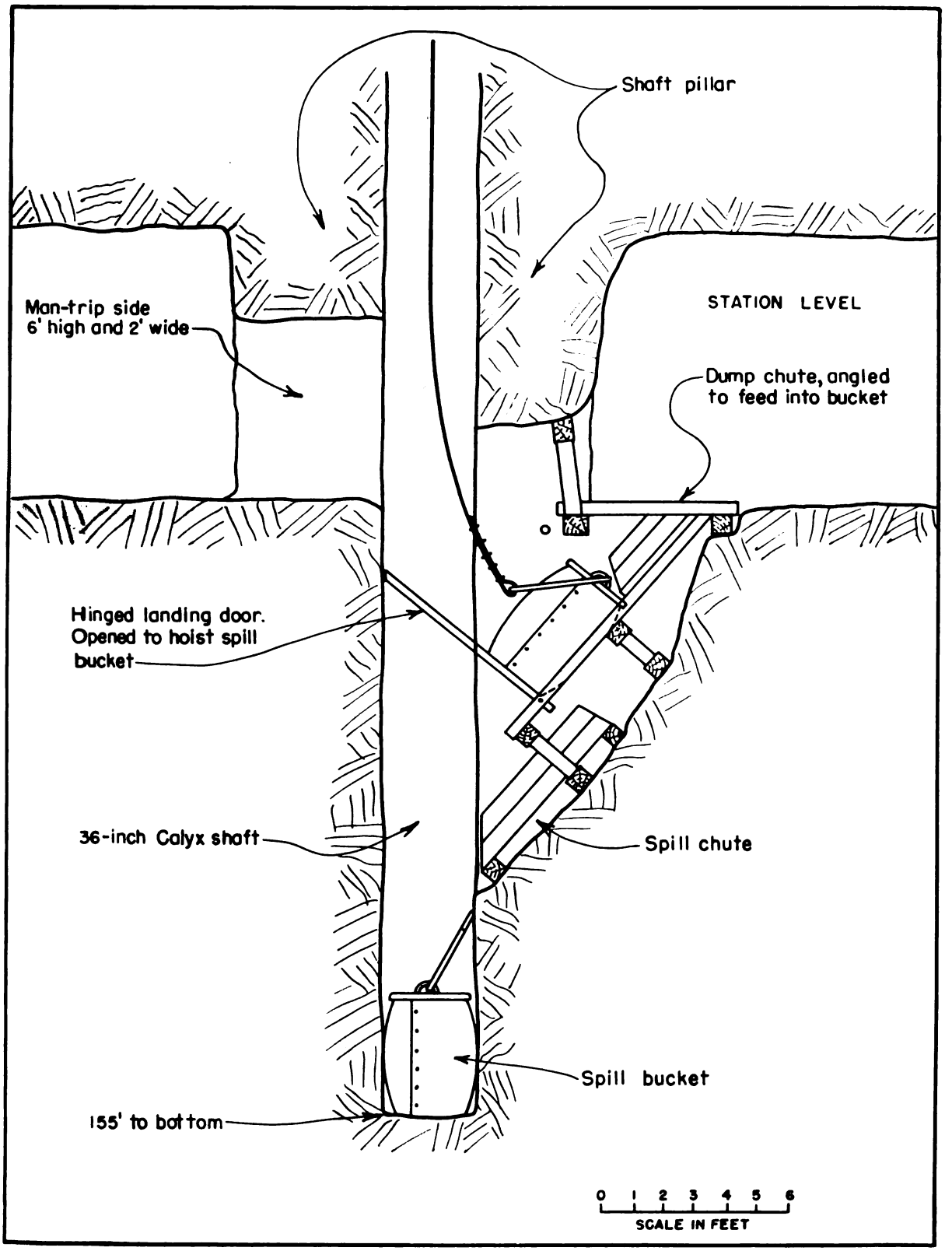

Figure 15. - Vertical section through shaft station and loading pocket, Calyx No. 8 mine.

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is a small spill chute. Any ore spilled is directed by this lower chute into a spill bucket, which rests on the bottom of the shaft. At the Calyx No. 3 mine the bucket rests upright at the bottom of the shaft, 12 feet below the station, directly under the chute lip.

The Scoot-Cretes never leave the underground workings. To get one underground it is disassembled on the surface and lowered in sections. The frame and dumpbox are cut into halves, lowered, and then welded back together underground. The scraper slides are also fabricated underground. The daily diesel-fuel supply and lubricating oil for the Scoot-Cretes are lowered each day in closed 5-gallon cans and kept at the shaft stations. The average fuel-oil consumption of a Scoot-Crete is 2-1/2 to 3 gallons for an 8-hour shift.

Hoisting

The ore is hoisted in 20-cubic-foot-capacity hoisting buckets at both mines. There are no guides in the shafts, and the buckets travel free without crossheads. The buckets are about 33 inches in diameter and travel smoothly in the shaft with little jarring against the sides. The miners enter and leave the mines by riding the buckets.

The 4-post-type headframe at the Calyx No. 3 mine is 20 feet high and built of riveted steel-truss members (see fig. 16). The small third-motion hoist has a single 20-inch drum with a single-band brake and a jaw clutch. It is driven by a 6-cylinder, gasoline, Ford Industrial engine, estimated at 100 horsepower. Hoist cable is 3/4 inch. Hoisting speed is about 150 feet a minute. When the bucket has been loaded and the hoist signal given, it takes an average of 1 minute 20 seconds to hoist the bucket, dump it, and return it to the bottom.

The headframe at the No. 8 mine is an A-type wooden structure, 22 feet high to the crown cap (see fig. 17). The vertical front posts are 10- by 12-inch timbers, and the rear posts are 8- by 8-inch timbers. The small third-motion hoist has a single 24-inch drum, with a single-band brake and band-friction clutch (see fig. 18). The hoist is driven by an automobile engine through a standard automotive transmission and clutch assembly. The automotive transmission is shifted into the low forward gear when hoisting and is clutched to its reverse gear when lowering. Hoisting cable is 3/4 inch. Hoisting speed is also about 150 feet per minute.

The hoisting buckets are dumped at the surface by a simple, self-dumping device. After the bucket is hoisted into position, a steel dump plate, hinged across the front-headframe posts, is pulled by an attached cable to swing to a 45° angle across the headframe and over the shaft. The notch in the swinging edge of the plate engages the washer chained to the bottom of the bucket. As the bucket is lowered, it strikes the upper end of the plate off center and tips toward the lower and hinged end of the plate. As the bucket tips, its moment pivots the plate outward, and the partly inverted bucket empties into a dump truck positioned below the bucket. The ore from both mines is dumped at surface stockpiles, whence it is hauled to the railpoint in Green River.

The maximum number of buckets of ore hoisted in 1 shift at the Calyx No. 3 mine was 163. This means that 1 bucket of ore was hoisted every 2.9 minutes during the shift.

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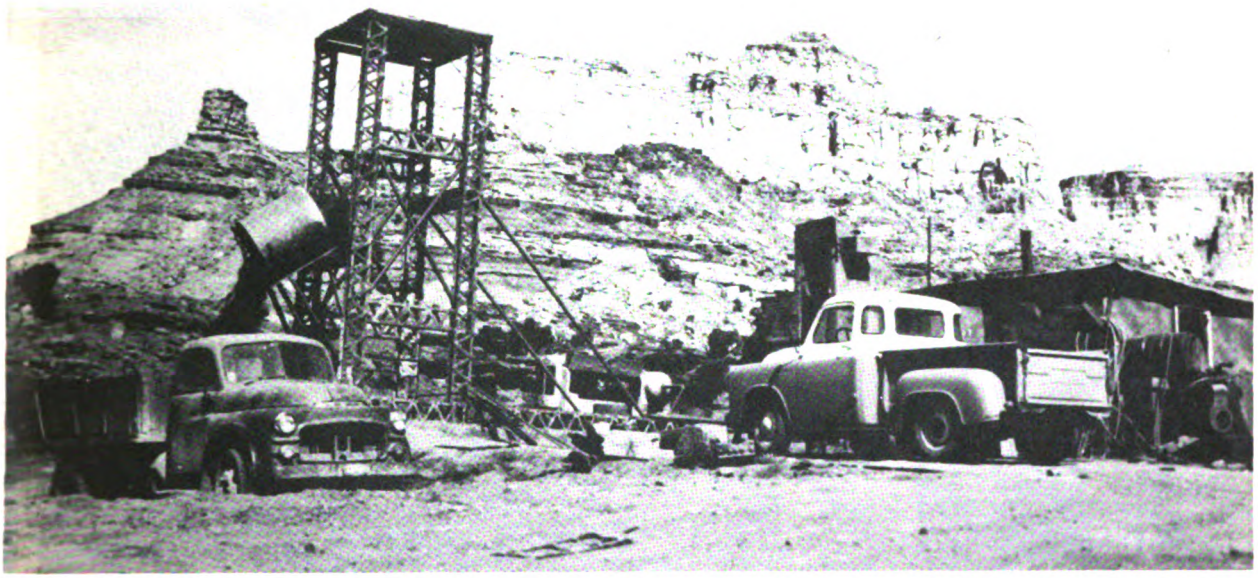

Figure 16. - Headframe at Calyx No. 3 shaft; South Temple Mountain in background.

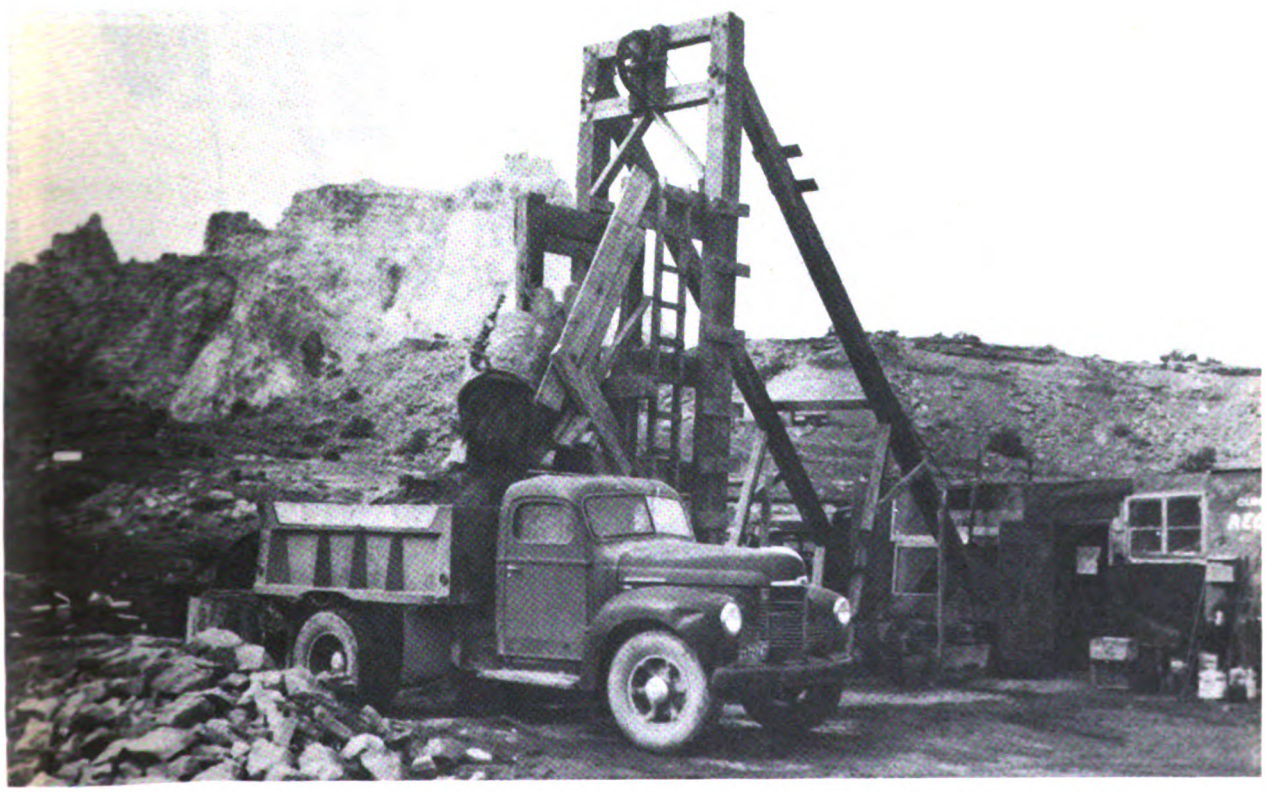

Figure 17. - Headframe at Calyx No. 8 shaft; North Temple Mountain in background.

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Figure 18. - Single-drum hoist at Calyx No. 8 shaft.

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SURFACE PLANT

Surface-plant structures at both mines are small and inexpensive, but adequate. The hoists at both mines are enclosed in 12- by 20-foot wooden buildings, which also serve as small warehouses. At the Calyx No. 3 mine machinery repairs are made in a 20- by 30-foot wooden shop building.

Compressed air is furnished at the Calyx No. 3 mine by 3 compressors, although usually just 2 are operated at one time. They have a 315-c.f.m., Gardner-Denver, stationary compressor, driven by a 4-cylinder General Motors diesel engine; a 315-c.f.m., Ingersoll-Rand stationary compressor driven by a 4-cylinder, General Motors diesel engine; and a 315-c.f.m., Chicago Pneumatic portable compressor driven by a Caterpillar, model D8800, diesel engine. Cline & Co., at the Calyx No. 8 mine, has a 500-c.f.m., Gardner-Denver stationary compressor driven by a General Motors 6-cylinder diesel engine.

Water for mine use is furnished by the lessor from the well at the mine camp; each lease operation is charged $60.00 a month for this service.

The ore is transported by contract truckers for $0.06 a ton-mile to the Green River loading point on the Denver & Rio Grande Western Railroad, a distance of 40.5 miles. It then is shipped to the Vitro Uranium Co. mill in Salt Lake City.

SUMMARY TOTAL OF EQUIPMENT AND SUPPLIES

Mining equipment used at the Calyx No. 3 mine consists of the following items:

Number	Equipment item
1	Hoist, single 20-inch drum, band brake, jaw clutch, Ford Industrial engine.
1	Compressor, 315-c.f.m., 2-stage, skid-mounted, Gardner-Denver, model WBO, with 4-cylinder GMC diesel engine, model 4029.
1	Compressor, 315-c.f.m., 2-stage, skid-mounted, Ingersoll-Rand, model 75-3H, with 4-cylinder GMC diesel engine, model 4031-C.
1	Compressor, 315-c.f.m., 2-stage, portable, Chicago Pneumatic, with Caterpillar diesel engine, model D8800.
3	Scoot-Crete Ore Carrier, model D-52.
3	Scraper hoist, compressed-air, 2-drum, 5-hp., Gardner-Denver, model HEE.
3	Scraper hoist, compressed-air, 2-drum, 5-hp., Ingersoll-Rand, model A5NN-OH.
3	Scraper hoist, compressed-air, 2-drum, 7 1/2-hp., Ingersoll-Rand, model HNN1J.
3	Tugger hoist, compressed-air, 1-drum, Gardner-Denver, HB, HKL, HK.
9	Rock drill, jack-leg-mounted, Ingersoll-Rand JR-38, Cleveland H10AL, and Gardner-Denver S48 with FL2B leg.
1	Rock drill, stoper, Gardner-Denver, R-94.
4	Fans, centrifugal, Coppus, type TM and TP-6.
1	Dump truck, 6-ton.
1	Hoist, single-drum, Vulcan (at No. 12 shaft).

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Mining equipment used at the Calyx No. 8 mine consists of the following items:

Number	Equipment item
1	Hoist, single 24-inch drum, band brake, friction clutch, gasoline automotive engine.
1	Compressor, 500 c.f.m., 2-stage, stationary, Gardner-Denver, with 6-cylinder, GMC diesel drive.
4	Scoot-Crete Ore Carriers, model D-52.
3	Scraper hoist, compressed-air, 2-drum, 5-hp., Ingersoll-Rand.
4	Rock drill, jack-leg-mounted, Ingersoll-Rand, JR-38, J40 and J50 with JL-3 legs, and Cleveland H10AL.
8	Fans, centrifugal, Buffalo No. 3 and Coppus TP-6.
1	Dump truck, 6-ton.

Dynamite consumption for the 2 mines averaged 2.8 pounds per ton of ore during the periods for which unit costs were calculated.

VENTILATION

The mine workings are ventilated by natural and by mechanical methods. The interconnected workings of the mines provide a number of openings to the surface, and fresh air flows by natural means along the principal haulageways. Positive ventilation is necessary to dilute diesel exhaust gases and radioactive concentrations in the working areas. Small, centrifugal blowers, mounted on the surface at the collars of small-diameter drill holes, blow fresh air underground (see fig. 19). The holes are rotary-drilled and range from 4 to 8 inches in diameter. The fan sizes are Buffalo No. 3, Coppus Ventair TP-6, and similar types. Various makes and models of small gasoline engines are used to drive the fans. The fresh air takes irregular routes to the exhausting shafts because of the erratic extent of the workings. As the workings are advanced, new holes are drilled so that fresh air is delivered near the face. At the Calyx No. 8 mine as many as eight blowers are in operation.

The depths of the ventilating holes range from about 130 to 180 feet at Calyx No. 8 and from about 100 to 230 at Calyx No. 3. The unit contracting cost for drilling an 8-inch rotary hole is about $3.50 a foot.

LABOR CLASSIFICATIONS AND WAGES

Calyx No. 3

An average of 13 men, working a 1-shift operation, is employed at the Calyx No. 3 mine. This number does not include the shifter or the superintendent. The following lists the average number of men employed at each job classification:

Classification	No. of men	Hourly base wage
Mechanic	1	$2.50
Hoistman	1	2.16
Driller	3	2.20 and 2.10
Scoot-Crete operator	3	2.00
Scraper operator	4	2.00
Mucking-machine operator (also scraper)	1	2.10
Total	13	

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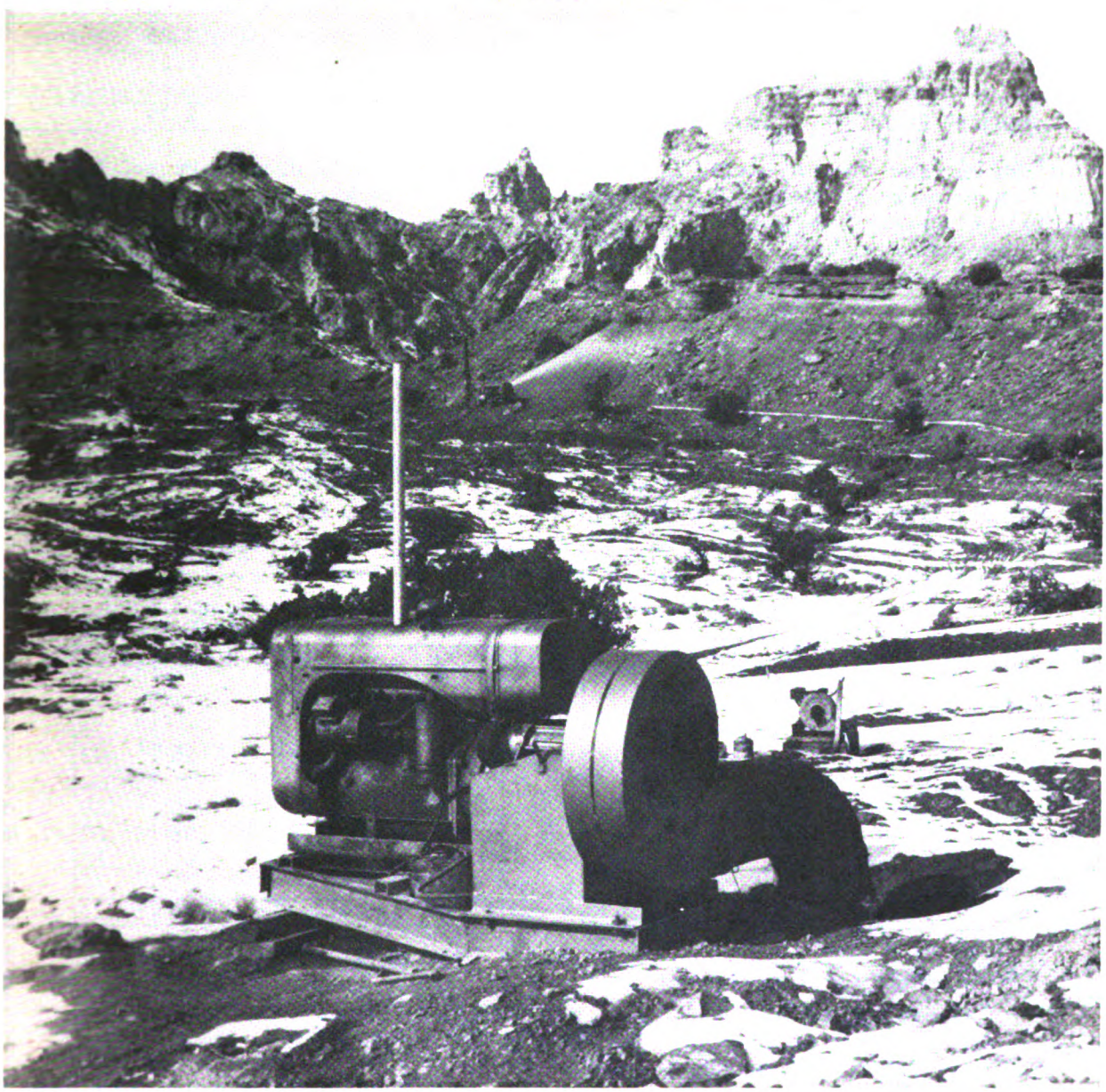

Figure 19. - Small centrifugal blowers placed at collars of drill holes, Calyx No. 8 mine.

The men work 12 shifts on and 2 off. American Leduc Uranium Corp. is required by its lease agreement to employ a minimum number of men. This company often drives development headings under a contract-bonus system, paying the miners $8.00 per foot of advance, with the company furnishing all supplies and haulage labor.

Calyx No. 8

An average of 7 men is employed at the Calyx No. 8 mine. This number does not include Melvin Cline, lessee. They also work a 1-shift operation, with 12 shifts on and 2 off. The job classifications follow:

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Classification	No. of men	Hourly base wage
Mechanic (also scraper operator)	1	$2.50
Hoistman	1	2.25
Driller	2	2.25
Scoot-Crete operator	2	2.13
Scraper operator	1	2.19

The men employed at both mines live at the Consolidated Uranium Mines, Inc., camp. A majority of the miners have their families with them and live either in the leasor's cabins, paying $25.00 a month rent, or in privately owned trailers. Single men are charged $10.00 per month for bunkhouse facilities and $1.00 per meal at the camp cookhouse.

Labor turnover is moderate; it is sometimes difficult to obtain good miners.

SUMMARY OF COSTS

Mine: Calyx No. 8 — Mining method: Horizontal open stoping with casual pillars

Ore hoisted: 7,664.41 tons — Period: April 1 to November 30, 1955

1. Direct costs per ton of ore hoisted:

	Labor	Supervision	Compressed air[1]	Bits and steel	Explosives	Fuel and oil[2]	Water	Repairs and expend. equip.	Other supplies	Total
Development[3] ...	[4]$0.51	$0.10	$0.05	$0.03	$0.11		$0.01	$0.11	$0.03	$0.95
Mining:										
Drilling and blasting	.77	.15	.08	.20	.63		.05	.26	.03	2.17
Scraping and loading	1.26	.16	.14					.03	.10	1.69
Tramming	.81	.14				$0.03		.38	.02	1.38
Hoisting	.56	.08				.08		.01	.03	.76
Ventilation						.05		.01		.06
Total	$3.91	$ .63	$ .27	$ .23	$ .74	$ .16	$ .06	$ .80	$ .21	$7.01

2. Indirect cost per ton of ore hoisted:

Payroll taxes	$0.23
Other taxes and workman's comp. ..	.51
Insurance, equipment	.18
Truck and auto expense	.17
Assaying and umpire costs	.03
Office costs and accounting	.06
Total	$1.18

1/ Consists principally of fuel-oil costs.

2/ Fuel oil and lubricants used in equipment other than for compressor.

3/ Development costs are not unit costs per ton of development ore but are costs of development work charged against total tons mined.

4/ Development labor includes drilling, blasting, scraping and tramming, and underground exploratory drilling.

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Mine: Calyx No. 3 — Mining method: Horizontal open stoping with casual pillars

Ore hoisted: 26,803.22 tons — Period: September 1955 to February 1957

1. Direct costs per ton of ore hoisted:

	Labor	Supervision	Compressed air[1]	Bits and steel	Explosives	Fuel and oil[2]	Water	Repairs and expend. equip.	Other supplies	Total
Development[3] ...	[4]$0.44	$0.09	$0.07	$0.03	$0.09		$0.01	$0.08	$0.03	$0.84
Mining:										
Drilling and blasting	.67	.11	.13	.15	.63		.05	.09		1.83
Scraping and loading	1.25	.22	.19					.14	.07	1.87
Tramming	.72	.11				$0.03		.22	.03	1.11
Hoisting	.41	.07				.08		.05	.03	.64
Equipment maintenance ...	.46	.08				.02		.20		.76
Ventilation						.05				.05
Total	$3.95	$ .68	$ .39	$ .18	$ .72	$ .18	$ .06	$ .78	$ .16	$7.10

2. Indirect cost per ton of ore hoisted:

Payroll taxes and workman's comp. ..	$0.50
Utah production tax	.11
Welfare and vacation pay	.01
Surface structures	.03
Engineering and surveying	.04
Truck and traveling expense	.18
Legal, accounting, and manager's expense	.41
Office expense	.06
Assaying and umpire costs	.04
Total	$1.38

1/ Consists principally of fuel-oil costs.

2/ Fuel oil and lubricants used in equipment other than for compressor.

3/ Development costs are not unit costs per ton of development ore but are costs of development work charged against total tons mined.

4/ Development labor includes drilling, blasting, scraping and tramming, and underground exploratory drilling.

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Mine: Calyx Nos. 3 and 8[1/]

Ore mined: 34,467.63 tons[1/]

Mining method: Horizontal open stoping with casual pillars

Period: Calyx No. 3 - Sept. 1955 to Feb. 1957
Calyx No. 8 - April 1955 to Nov. 1955

3. Summary of direct costs in units of labor, powder, and supplies:[1/]

	Development[2/]	Mining	Total
A. Labor (man-hours per ton):			
Underground			
Drilling and blasting		0.35	
Scraping and loading		.59	
Tramming		.30	
Hoisting		.22	
Total, underground	0.20	1.46	1.66
Equipment maintenance			.17
Supervision			.14
Total, all labor			1.97
Labor (tons per man-shift):			
Underground labor			4.8
Equipment maintenance and supervision			25.8
Total, all labor			4.1
Labor and supervision, percent of total costs			55.7
B. Supplies:			
Explosives (45 percent semigelatin), pounds per ton			2.8
Fuel oil, gallons per ton			1.3
Supplies, percent of total cost			44.3

1/ The costs in units of labor and supplies shown on this page are the average of both operations.

2/ Development units are based on development labor charged against total tons mined.

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